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SCIENTIFIC REPORTS

OF THE

Indian Agricultural Research Institute, New Delhi

For the year ended 30th June, 1946

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SCIENTIFIC REPORTS

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Indian Agricultural Research Institute, New Delhi, for the year ended 30th June, '46

REPORT OF THE DIRECTOR

I. INRODUCTORY

This report describes as usual the scientific and training activities of the Institute. Reference has been made in the last report to the plans for the expansion of the teaching and research activities and to the sanctions given in July 1945 to proposals for increased teaching facilities. The chief purpose of this Institute is to conduct research in the different agricultural sciences, to provide facilities for advanced training and to undertake such surveys and bureau type of activities which are conducive to the promotion of agricultural research. The research and teaching organisation of the Institute should therefore reflect a representative cross-section of the theory, technique and practice of the science and industry of agriculture.

The dearth of trained scientific men is recognised to constitute an important limiting factor in our plans of development and the aim of the ultimate organization of the teaching and research activities of the Institute should be the provision of facilities in all the branches of the Agricultural Science which are of major importance. In addition provision has to be made for such research and enquiries which Government may consider to be necessary in connection with their plans of agricultural development and come within the purview of this Institute.

After reviewing the set-up of the Iustitute my first duties as Director were therefore to draw up a scheme of postwar expansion to enable the Institute to fulfil its functions as a major centre of fundamental research and advanced training. These plans have been submitted to Government for their consideration. The requirements of the Institute in this regard have been drawn up in the form of a 5-year plan of development providing for "Immediate" (1946-47) and "future" (1947-52) needs A beginning has been made with the organization of the Division of Agricultural Engineering. The Agricultural Engineer took up his duties early in November 1945. The post of the Head of the Division of Agricultural Economics had also been already sanctioned. A Soil Survey Unit has been created in the Division of Soil Science and Agricultural Chemistry and the Unit of Plant Physiology in the Division of Botany has been raised to the status of a Section. The postgraduate courses of studies have been reorganized on the basis of estimates of teaching requirements for each course and expanded facilities for training have been provided for. The course of studies in each subject provides for theoretical instruction, practical classes, field work and training in research methods Arrangements have been made to provide a background of knowledge in the cognate sciences in addition to the actual courses of studies in a particular subject. The one-year course in Agriculture has been replaced by a 2-year course covering a wider curriculum and is now thus similar to the courses offered in the other Divisions. The proposed one-year course in Plant Protec-

tion conducted jointly by the Divisions of Entomology and Mycology has been introduced.

As usual, the work of the Institute during the year is described in the accompanying reports of the different Divisions and they show that progress has been maintained.

Amongst the distinguished men who visited the Institute were :—

H. E. Sir John Colville.	Viceroy's House, New Delhi.
Lady Colville.	,, ,,
W. F. Dickson, Esq.	Agricultural Adviser, American Mission, New Delhi.
Mukhi Gobindram Pritamdas, Esq.	Member to Govt. of Sind, Karachi.
T.Bergen, Esq.	American Mission, New Delhi.
Reu-Ching Gao, Esq.	National W.C.A. Chungking, China.
Lu Givei Djew, Esq.	British Scientific Mission in China.
F.W. Robertson, Esq.	Federal Public Service Commission.
M.A R ahman.	,, ,, ,,
M.K. Sen Gupta, Esq.	Financial Commissioner Communications 7, York Road, New Delhi.
Major A.J.Wavell	The Black Watch, Viceroy's House.
General Arthur Wanchope	Viceroy's House.
Sir Lewis L. Fermor, F. R. S.	Bristol.
Sir Clarence A. Bird.	New Delhi.
Sir J. C. Ghosh	Indian Institute of Science, Bangalore
Tibetian Mission.	Lhasa, Tibet.
Sir I. H. Mackay.	H. C. for Australia in India, 24, Ferozshah Road, New Delhi.
Lawrence White, Esq.	Tropical Deteriorative Res. Laboratory, Philadelphia.
A. M. Evien, Esq.	Colonial Office, Delhi.
U. O. Kaig, Esq.	Univ. of Reading, England.
Dr. Prafulla Chandra Ghosh (A.I.C.C.)	Calcutta.

II. RESEARCH AND INVESTIGATIONS.

1. Agronomy and Cattle Breeding.

Nitrogenous manuring experiments.

In these field experiments comparison was made of the relative values of nitrogen in green manures, farm yard manure, compost, oil cakes and sulphate of ammonia, estimating the recovery of nitrogen by the crop and of the changes brought about in the soil.

(*a*) *Russell Experiment No. 1.*—This experiment was repeated with wheat, but three of the six blocks were limed at the rate of 300

lbs. slaked lime per acre. The object of the liming was to counteract the alleged adverse effects of the excess of potash in the soil and at the same time to increase the effectiveness of the available minor elements. The results, however, did not justify this assumption and, in fact, the liming had a depressing effect on the yields of wheat in many of the treatments.

(*b*) *Russell Experiment No. 2.*—This experiment was also repeated. In general the yields of wheat were lower this year than in the previous year, but as the amount of lodging was low, the crop in the ammonium sulphate treatment did not suffer as in the previous year and showed a significantly higher yield than that in the 'no manure' control. Rape cake also showed a similar response, but neither green manuring with sunnhemp and cowpeas nor farm yard manure and leaf compost showed any significant responses.

Phosphate manuring of legumes and its residual effects.

This series of experiments had provided very interesting and valuable results and the range of trials was expanded in order to follow up and clarify further the results obtained and observations already made. The striking effects of phosphates on yields when applied to legumes and in increasing their phosphate and calcium contents, as also in developing a stable type of soil fertility for following crops have been well established by the experiments carried out in the Division of Agriculture over the last six years.

Other Manurial experiments.

Experiments on the manurial values of ammonium nitrate alone and containing certain percentages of T.N.T. were compared with sulphate of ammonia. These experiments were started in 1944-45 at the suggestion of the War Department of the Government of India to assess the manurial values of these explosives, large quantities of which were expected to be available after the War. Trials were made with paddy and sugarcane at Karnal and wheat, cotton and sorghum at Delhi. For equal amounts of nitrogen, ammonium nitrate and its mixtures with 1,2,3 and even 20 per cent T.N.T. was found as effective as the standard fertilizer sulphate of ammonia. No deleterious effects to crops were observed by the introduction of T.N.T. at three different percentages.

Experiments on the manurial value of Oklanite, Digested Sludge and Activated Sludge were also undertaken. The test crops were barley, wheat and peas. It was found that all the three types of sludges have high manurial values and compare favourably with standard fertilisers such as sulphate of ammonia from the point of view of nitrogen, and superphosphate as regards phosphate.

Yet another set of experiments on direct and indirect manuring of paddy in different rotations were carried out. These experiments were started at Karnal in 1944-45 and continued during the year under report. The rotations under trial were (i) Paddy-Fallow, (ii) Paddy-wheat, (iii) Paddy-berseem, (iv) Paddy-peas and (v) Paddy-gram. The manurial treatments in rotation (ii) Paddy-Wheat, included sulphate of ammonia, ammonium phosphate, superphosphate, bonemeal and combination of sulphate of ammonia with superphosphate and with bonemeal, nitrogen being added at 40 lb, or 80 lb.N and phosphate at 80 lb. P_2O_5 per acre. The fertilisers were applied to both the crops. The highest yield of paddy (29·7 maunds per acre) was obtained from the sulphate of ammonia treatment at 80 lb. N. The yield of paddy from the control plot was 27·6 maunds to the acre, this high yield being due to the effect of the previous

crop of berseem. The highest yield of wheat (24·2 maunds per acre) was obtained from the ammonium phosphate treatment, but low yields of 14·0 and 12·9 maunds per acre were obtained respectively from the superphosphate and bonemeal treatments. The yield from the control plot was 15.4 maunds.

In the paddy-legume rotations the manurial treatments included superphosphate and bonemeal at 80 lb. P_2O_5 applied to the legume with and without sulphate of ammonia at 40 lb. N applied to the next crop of paddy, ammonium phosphate applied to the legume and also no fertilizers applied to the legume but ammonium sulphate or ammonium phosphate applied to the succeeding crop of paddy. In general, the yields of paddy were higher in the paddy-legume rotations than in the paddy-fallow rotation, indicating the value of a suitable legume in the rotation to step up crop production. The legumes have shown a good response to phosphates but phosphates have been ineffective in these soils when applied to cereals direct.

An experiment on the effect of dipping paddy seedlings in night soil and other manures before transplanting was started in 1945-46 at the suggestion of the Government of India, based on the observations made by the Indian Agricultural Mission to China. It was reported that in certain tracts the Chinese cultivator dipped the roots of paddy seedlings in a mixture of equal parts of night soil, wood ashes and ordinary soil before planting them out, the underlying idea being to give a good start to the growing seedlings. The yield of paddy obtained at Karnal from the various treatments shows that the dipping of seedlings in a solution of night soil, wood ashes and ordinary soil improved the yield of paddy by about 4·9 and 3·5 maunds per acre in series I and II respectively. The practice appears worth further examination. It may be found possible to replace night soil by mixtures to which objection in handling is not raised by Indian cultivators.

Green Manuring experiments.

As a means of supplementing the inadequate supply of organic manures in India, the possibilities of green manuring call for examination. At the suggestion of the Hon'ble Sir Jogindra Singh, late Member In-charge of the Department of Agriculture, a trial was made at the Delhi farm to evaluate the response of sunn-hemp grown *in situ* or brought from another field for green manuring or for composting this material before using as a green manuring. In the experiment its use merely as a mulch covering was also examined. The sunnhemp grown *in situ* and used as artificial mulch produced the highest outturn of 33 maunds of wheat per acre, whereas that brought from outside and used as mulch gave only 28·6 maunds per acre. Sunnhemp composted before burying gave a yield of 30·7 maunds of wheat per acre. The initial fertility of the soil in this particular field being high, a yield of 28·5 maunds per acre was secured from the 'no green manure' treatment Green manuring with sunnhemp brought from outside was more effective than when sunnhemp for the purpose was grown *in situ*. The object of the experiment was to see whether waste lands such as that on either side of the railway lines could be used for growing green manure crops, which could be carried to the villagers' field with or without composting it, and used for green manuring purposes.

Flood water farming experiments.

These experiments were continued both at Delhi and Karnal. The results so far achieved have shown the possibilities of using water taken from the rivers during the monsoon flood period to make up deficiencies in the rainfall in precarious areas. The object of such irrigation is two-fold, viz. (i) to provide

water for the standing *kharif* crops, whenever the rains are in defect and (ii) to water the fallow fields being prepared for *rabi* crops sufficiently to moisten the soil to the depths required to meet all the future demands of wheat, barley, gram, oil-seeds, grown under *barani* (rain-fed) conditions. These requirements are : (i) Sufficient moisture in the surface soil to guarantee good seed germination at sowing time which is about the end of October and (ii) water extending to sufficient depths in the soil to provide the necessary stores of moisture for growing and bringing the crops to maturity. Since there are usually ample supplies of water in the rivers of Northern India during the monsoon which now largely go to waste, the quantity of water which can be so used at present is dictated more by the carrying capacity of the canal system to be provided than by any limitations of the water supply.

Mixed Farming Experiments.

These experiments were continued, as usual, in a 8-acre holding at Delhi and three holdings respectively of 8, 25 and 400 acres at Karnal.

Tillage Experiments

Tillage cum Manurial Experiment at Karnal: This experiment was continued with the object of studying the relative merits of three alternative forms of tillage. The main treatments being (1) power cultivation with tractor ploughs and other tractor-drawn implements, (2) bullock cultivation with soil inversion (Victory) plough supplemented with country plough, and (3) bullock cultivation without soil inversion by country ploughs. The detailed results are given in the report of the Division of Agriculture.

A cultivation experiment using tractor ploughs and country ploughs at different periods was carried out at Karnal, the crop concerned being paddy. The total area under this experiment was 15 acres. During the year under report paddy I. P. 97 gave average yields of 24·7 and 24·4 maunds per acre respectively from the tractor-ploughed plots and plots cultivated with the country ploughs.

Ley Farming and Alternate Husbandry.

In many countries much attention has been given to the development of this system of farming in recent years. In alternate Husbandry grasses are used either alone or in combination with legumes in leys of 2 or 3 or more years duration under suitable fertilizer treatments for the production of protein rich fodder and for the accumulation of soil fertility for succeeding food and commercial crops.

A beginning has been made at Delhi with Rhodes grass in a lucerne and berseem mixture during 1945-46 under different fertilizer treatments. The nitrogenous fertilisers were applied to the Rhodes grass which grows during the summer and phosphate to the legumes which gave a further crop in the winter. Two crops are thus obtained in the course of one year.

The Rhodes grass was planted out in a field which had been under lucerne continuously for four years. In the control plots the average yield of green grass per acre was nearly 326 maunds. A direct response was seen wherever nitrogen had been applied, but there was no response to P or K in the absence of N. The highest yield of nearly 531 maunds was obtained from the ammonium phosphate treatment and the second best from the sulphate of ammonia treatment.

The yields of the lucerne-berseem mixture are rather low, but unlike the

grass there is no response to nitrogen, but a definite one to P, either alone or in combination with K. The experiment is being continued.

Cattle Breeding

On 1st July 1945 the strength of the Sahiwal herd at New Delhi was 291 head and on 30th June 1946 it was 295. For the last few years, due to difficulty in the disposal of male stock for breeding purposes the herd strength has steadily increased to 300 head. There is great demand for cows and they are easily disposed of. The demand for the young male stock however for dairy stock improvement is somewhat poor. The reason lies probably in the comparatively poor draft qualities of the Sahiwals. Efforts are being made to meet this by selection for definite dual purpose, draft and milk type. The success so far achieved indicates that there are hopeful possibilities along these lines.

There was a slight fall in the wet average yield being 8.7 lb. per cow per day, but a high percentage of cows was maintained in milk (70%) and the overall shows less decline, being 13.1 lb. for the year under report. Two outbreaks of foot and mouth disease interfered with production particularly in cases of cows in the flush period on the yields of which the maintenance of the wet average depends.

Two cows yielded over 10,000 lb., one over 9,000 lb. and six over 8,000 lbs. in a lactation period of 306 days. Two heifers yielded over 8,000 lb., four over, 7,000 lb. and three over 6,000 lbs., in 306 days.

As regards the Tharparkar herd, the herd strength on 1st July, 1945 was 308 head and at the end of the year (30-6-46) it was 279.

The yield has been maintained at a high standard in spite of the effects of foot and mouth disease. The percentage of cows in milk averaged 71% throughout the year and the overall average (wet and dry) is maintained at 15.1 lbs. per head per day, the wet average being 21.1 lb. per head per day.

During the year 37 adults and 2nd calvers completed lactation. Four of the above were badly affected with foot and mouth disease. The remaining 33 gave an average lactation yield of 6849 lb. in 306 days Three of these gave more than 8,000 lb. and seven above 7,000 lb. There were 27 heifers completing lactation. Of these two lactations were short owing to foot and mouth disease. In the heifer group seven gave yields over 7,000 lb. and 10 above 6,000 lb. The average for the 27 heifers was 6732 lb. per lactation.

2. CROP IMPROVEMENT.

A. Crops other than Sugarcane

Wheat collections.

The study of the all-India collection of wheats was continued. The comparative study of a number of selected wheats at Delhi, Pusa and Coimbatore was repeated. In a study of the performance of two sets of six varieties each at Delhi, the seed of one of which came from Coimbatore (previous season's crop), a marked difference in the performance was noticed. At Simla, the studies on hill wheats were continued. The varieties of wheat under study for registration were grown and described as in the previous years.

Studies on wheat and allied genera.

The F_8 generation of the intergeneric hybrids, *Triticum vulgare* × *Secale. cereale* and *T. vulgare* × *Aegilops caudata* was studied and promising plants possessing economically valuable characters like high tillering, long ears, amber

and red-coloured well-filled grains and resistance to rust were isolated and selected. The plants resembling *T. sphærococcum* obtained in the progeny of *T. vulgare* × *Aegilops caudata* were studied and selections were made for further observations. The study of the inheritance of 'branched ear', 'extra glume' and 'glume colour' was continued in the crosses of *T. Vavilovi* × *T. vulgare* and *T. Vavilovi* × *T. sphærococcum*. From the collection of grasses allied to *Triticum, Agropyron intermedium, A. elongatum* and *Elymus juncæ* were studied with regard to their photo requirements. Suitable selections were made from the progenies of different interspecific crosses involving *T. Vavilovi, T. durum* and *T. Timopheevi*.

Breeding for Disease Resistance and other qualities.

The testing of wheat varieties, including new strains of hybrid origin, for resistance to loose smut was continued. Selections of hybrids found resistant to rust after actual inoculation tests, were also made. Work on rust-resistant wheats for the hills was carried out at Simla in collaboration with Dr. K. C. Mehta. A number of promising plants were selected from the F_2 progenies of crosses between Baluchistan local wheats and I. P. and other wheats.

A large number of potato hybrids evolved at the Simla Sub-station were under study. At Delhi selections were made from 1530 hybrids. At Pusa hybrids superior to local varieties were isolated. In yield trials with 61 hybrids a few showed superiority over local varieties. Grafts involving potato, tomato, some tobacco species and other solanaceous plants were made with a view to producing chimeral shoots. At the Potato and Wheat Breeding Sub-station, Simla, besides studies in the Indian and European collections and hybrid trials, a new method for propagating the potato by sprouts and sprout cuttings was developed.

In the study of resistance to wilt of the pigeonpea the hybrid C 38-3-1 appeared to be completely immune.

110 newly-evolved strains of linseed were tested for resistance to rust; only 2 showed slight infection at Karnal and one at Delhi, whereas the I. P. types and other cultures were affected to varying degrees. Suitable selections were also made from the progeny of the F_4 generation of the crosses between I. P. types and the imported variety Bolley Golden.

Selections were made for high nicotine content from the F_7 progenies of the intervarietal crosses in *N. rustica*. At Pusa promising selections for further breeding work were made from the F_7 progenies of the various cigarette tobacco crosses. At Guntur the varietal trials with Harrison's Special, Yellow Twist, improved Yellow Mammoth, Amarello 5 and Hybrid 1, the last two gave the highest yield and the highest percentage of bright leaf. Selections for resistance to mosaic were made from the progeny of the cross Harrison's Special × Ambalæma.

Cytogenetical studies in the Brassicæ.

The All-India collection of species and varieties of *Brassica* was again studied to confirm the tentative system of their cyto-taxonomic classification which has been worked out in the Botany Division. Inbred progenies of diploid types of *toria* (*B. campestris* var. *toria*) and *sarson* (*B. campestris* var *sarson*) were under study; these will be studied from the point of view of production of vigorous hybrid combinations. Cytological features and the inheritance of a 'dyad' mutant, a 'clumped pollen' mutant and a number of male-sterile mutants in diploid *toria* were under study. Inheritance studies were

also in progress with regard to the olive-green colour of the plant in *sarson* and *toria* and self-sterility in taramira (*Eruca sativa*).

Colchicine-induced polyploids obtained in a number of *Brassica* species were under study with special reference to fertility and other economic characters and selections for these characters were made. The nature and causes of seed-sterility in relation to cytological behaviour in autotetraploid *toria* were being studied ; intravarietal and intervarietal crosses were also made with a view to studying the effect of the diversification of the self-sterility genes on fertility in autopolyploid populations. Comparative study of growth and development in diploid and autotetraploid *toria* was commenced.

Fundamental Cytogenetical Research.

The C_8 generations of colchicine-induced autotetraploids of gram (*Cicer arietinum*) and chilli (*Capsicum annumum*) and the C_4 generation of autotetraploid sesame (*Sesamum orientale*) were under study particularly from the points of view of cytology, fertility and economic characters. In chilli, polyploidy was induced in a number of distinct types, the object being to study the effect of *inter se* hybridisation among these polyploids of fertility.

The amphidiploid, *Sesamum indicatum* (2n=58) obtained by 'doubling' the sterila hybrid between the cultivated *til*, *S. orientale* (2n=26), and the wild, resistant species, *S. prostratum* (2n=32) was being studied in respect of its morphological features and cytological and breeding behaviour. It was back-crossed to *S. orientale* and the back-cross progenies were grown and studied. There was evidence to indicate that characters from the wild species were transferred to the cultivated *til* ; the extent of this transference was, however, very limited. Further studies will be directed to combine the disease resistance of the wild species with the commercial qualities of the cultivated sesame. Back-crosses of the amphidiploid to *S. prostratum* and to autotetraploid *S. orientale* were also made and studied.

Physiological Investigations.

It was found in investigations on drought resistance that when wheats of different varieties were subjected to artificial soil drought in the early stages only, there was hardly any effect on their subsequent growth and yield. When the drought was given in the shooting stage, considerable reduction in the grain yield and 1000-corn weight was effected in the case of late varieties. When the early varieties were made late and the late early by vernalisation and different photoperiods, it was found that the former produced shrivelled grains whereas the latter produced well filled and plumps grains thus demonstrating the predominant effect of temperature during the ripening period on the development of the grain.

In a field trial, pre-treated seed (the treatment has been described in previous reports) of I. P. 4 wheat gave a grain yield of 1556 lbs. per acre as against 1245 lbs. from the ordinary seed.

In a complex experiment with 7 light treatments and 9 varieties of 6 different species of wheat, it was observed that the rate of development, in the sense of Lysenko, increased with the amount of light and that it was correlated with the growth of stem, tillering etc.

It is proposed in the future to develop other lines of physiological research such as (1) factors other than climatic and nutritional controlling growth and development of plants. Both the aspects of this problem will receive consideration, *viz.*, application of synthetic hormones, and the role of hormones occurring naturally in plants ; (2) culturing *in vitro* of embryos from crosses

which do not normally give seed ; (3) nutrition of important crop plants ; (4) inheritance of physiological characters.

Investigations on hybrid vigour with a view to utilising the same in increasing crop production were continued with brinjal, bitter gourd and maize. Hybrid Vigour.

B. Sugarcane.

In the sugarcane × sorghum crosses, the sweet sorghums specially obtained from the East African Agricultural Institute, Amani, were utilized for the first time for crossing. In the sugarcane × bamboo crosses, three valuable bamboo derivatives were utilized for crossing with well-known Co. canes. Sugarcane Breeding.

Taxonomic studies on the position of *Erianthus* have shown that there are distinct characters which should serve to separate *Erianthus* from *Saccharum* and that such forms as *S. munja* and *S. arundinaceum* should be separated from *Saccharum* and placed under *Erianthus*. These studies have also given an indication as to the probable origin of *S. officinarum*, the thick or noble canes. From a similarity of taxonomic characters, *E arundinaceum* might be considered as a probable source of origin of the thicker class of cultivated canes. Taxonomic Studies.

In the cytogenetic studies the production of egg gametes with a chromosome number different from the normally expected has been investigated. From the cytogenetic studies a hypothesis on the probable origin of North Indian canes has been suggested, *viz.*, that these canes have evolved out of extensive hybridization between *S. officinarum* and *S. spontaneum*. Cytogenetic studies.

In the plant physiological studies, the photoperiodic treatments enabled the manipulation of the flowering time and with the help of irrigational and manurial treatments certain non-flowering varieties were made to flower fairly profusely. Physiological studies.

3. Soils, Fertilizer and Plant Nutrition Investigations.

Data collected by the soil survey section of the Chemistry Division on the soils and climatic conditions of the different Provinces and States were collated and written up. Soil studies.

Alkaline patches of soils at Pusa (calcareous soil) and at Karnal (sandy loam), were examined for their salt content at different periods of the year. Profile studies of the sandy loam at Karnal soil did not show very marked horizon differentiation. As a measure of controlling the movement of salts to surface horizons, experiments were conducted to examine the effect of mulching the patches with farm waste material. It was found that if such a material is spread during summer, the movement of salts to surface layers is controlled. In order however that the rains should wash away or leach out some of the salts the cover should be removed and converted into compost during rains.

In connection with the study of the absorption and retention of ammonia by certain Indian soils the ammonia-absorbing power of 19 Indian soils was examined and correlated with various physico-chemical properties viz., clay content, water holding capacity, base exchange and pH.

Studies on Fertilizers and Manures.

The influence of phosphatic fertilizers on soil fertility and crop composition when legumes are included or excluded from rotation was studied in lysimeter experiments. The manures used were ammonium sulphate and superphosphate supplied at 80 lbs. nitrogen and 100 lbs. P_2O_5 per acre respectively, for the wheat-marua-wheat rotation ; for the berseem-cowpea and wheat rotation, the treatments were no manure and super at 100 lbs. P_2O_5 per acre. This year the crops taken were wheat in the first series and berseem in the second series. Analysis of berseem showed that the berseem of the phosphate-treated plots recovered 143 lbs. of nitrogen per acre against 43 lbs. per acre by the crop from the unmanured lysimeter, as the application of phosphate has a great influence on the fixation of nitrogen by berseem. As for wheat it was found that NP treated wheat contained the highest percentage of nitrogen followed by N-treated, untreated and P-treated. These figures show that the application of P alone is not beneficial in the case of a cereal like wheat and it should be applied with nitrogen.

The relative values of nitrogen in different nitrogenous manures under field conditions as judged by the yields and composition of wheat were studied in another experiment. The manures, under trial were green manure, F. Y. M. compost, rape cake, and sulphate of ammonia, superphosphate and potassium sulphate. Rape cake gave the best performance, the next best being compost with mineral nitrogen and P_2O_5, followed by F. Y. M. and mineral N and P_2O_5.

Experiments with ammonium nitrate with T. N. T. a surplus ammunition product, were conducted both in 1944-45 and 1945-46 and showed that the presence of T. N. T. upto the extent of 3% had no harmful effect on wheat. Ammonium nitrate alone or with T. N. T. increased the yield of wheat very considerably over that of the control.

Microbiological studies.

These experiments which have been in progress for some time have indicated that the production of bacteriophage in soils depends on the kind of crop and its continuous growth for a certain period. Thus berseem, peas and *khesari* produced bacteriophage in 3 years in Delhi soil, while lentil took 5 years.

Inoculation experiments with soyabeans and cowpeas showed that while the former was benefited to some extent by inoculation both at Delhi and at Pusa, there was no effect on cowpea, indicating thereby that the soils under experiment had enough of cowpea organisms.

Insecticides.

A number of products were prepared from opium by chemical treatment of marc. One of these appears to be a good insecticide and further trials on a field scale are in progress.

128 samples of leaf and 84 samples of tobacco stems were examined for their nicotine content and were found to be very poor and unsuitable for the preparation of insecticides. This line of work will be expanded as a co-operative project between the Divisions of Chemistry, Botany and Entomology.

Butanol Production.

The experiments were continued and the effect of different metals was studied. Iron, magnesium, lead, copper, tin, zinc and aluminium in the form of bits at 0. 7% concentration had no adverse effect on organisms. Litharge at the same concentration inhibited butanol production. Zinc dust had an adverse effect in molasses mash but not in the case of maize mash thereby, showing that the adverse effect of metals depends on the kind of media and the form and nature of the metals.

4. INVESTIGATIONS ON PESTS OF PLANTS.

Insect vectors of leaf-curl.

Sida rohombifolia, Solanum nigrum, Hibiscus sabdariffa, H. esculentus (*Bhindi*); *Lycopersicum esculentum* (*tomato*) *Capsicum* spp. (*Chillies*), *Euphorbia* spp. and several crucifers were observed to be some of the important alternative hosts of *Bemisia tabacci,* the white-fly vector of tobacco leaf curl. Spraying trials with fish oil rosin soap, conducted at Nipani (Bombay) against this vector on tobacco ultimately saved 11-28% of the plants as compared with the controls. Plants grown in pots treated with various manures and exposed to this disease showed that those treated with phosphate and potash remained immune.

Insect Population studies.

A set of precision experiments have been devised to see if there is any differential zonal distribution of the spotted bollworms of cotton in a large field. Regarding the dynamics of development of the pest : (1) an equation has been worked out and it has been shown that the relationship between temperature and development more closely agrees with this equation than any other equation so far tried by others (2) an experiment has been devised to see whether development proceeds uniformly if all extrinsic factors are kept constant, (3) it has been shown that the pupal period of the pest is not appreciably affected by larval food, (4) a method of predicting the pupal period with the help of the biometer is being tested. Biometers for egg and larval stages of the pest were being improved. For the long range studies records were kept of the population fluctuation of the pest during the year along with useful meteorological and other data.

Pests of food stuffs.

Trials on the effect of preservatives on stored jowar showed that D.D.T. and 666 in the reduced doze of 1 : 40,000 not only killed adults of *Sitophilus oryzae, Rhizopertha dominica, Tribolium castaneum, Corcyra cephalonica* and *Sitotroga cerealella,* but also stopped infection from these pests for a further period of 8 months without affecting germination capacity of the grains. Mercury used as loose metal, or dispersed in chalk or used as an amalgam gave complete kill of eggs of *Corcyra cephalonica.* Fumigation with carbon bisulphide at the rate of 6 lbs., 4 lbs. and 2 lbs. per 1000 c. ft killed the adults of the above-mentioned five important stored jowar pests in 6 hours, 12 hours and 36 hours respectively during summer, but in winter months complete kill was obtained with the 6 lbs. dose in 18 hours and with 4 lbs. in 24 hours ; a dose of 2 lbs. did not kill these pests even in 48 hours.

A survey of the insect pests of dried fruits revealed the following important pests :—*Oryzaephilus mercator, O. surinamensis, Plodia interpunctella, Ephestia elutella* (*?*) *E. Cautella, Corcyra cephalonica, Triboluim castaneum* and *Stathmopoda* sp.

13 different species were found infesting stored pulses, of which four species of *Bruchus* viz. *chinensis, analis, affinis* and *pisorum* were the commonest. As preservatives, copper carbonate at the rate of 1 : 200 sodium fluosilicate at 1 : 15,000, D.D.T. and 666 at 1 : 40,000 gave complete kill of all *Bruchus* spp. and prevented further infestation. Fumigation trials with carbon-bisulphide and hydrocyanic acid gas showed that the former applied at the rate of 4-5 lbs. per 1000 c. ft. at 62°-71°F. and the latter at the rate of 1½ ozs per 100 c. ft. at 83°-87° with 24 hours exposure gave complete kill of adults, larvae and pupae of all these Bruchids.

Survey of Icerya Purchasi.

A thorough survey of the pest showed its absence in some parts of Assam, Bengal and Bihar. In Peninsular India, however, it was recorded from several places in Mysore State, Orissa and Madras Presidency.

Biological Control of the pests of Sugarcane.

In June, 1945 the egg parasitisation at Cuttack of the stem-borer, *Argyria sticticraspis* by *Trichogramma* parasite in the six and twelve liberations blocks was 14.3% and 30.65% and in the control it was 4.17% In December the corresponding figures were 53.35%, 88.12% and 3.83% In June, 1945, the stem-borer damaged 32.37%, 25.87% and 41.06% plants in the six liberations, twelve liberations and control blocks. Larval and pupal population of the stem-borer per acre worked out at 283.3, 216.65 and 616.65 in the six liberations, twelve liberations and control blocks. The yield of cane in the six liberations, twelve liberations and control blocks were 597.25 maunds, 716.0 maunds and 440.7 maunds per acre. The experiments are being continued.

In the *Pyrilla* parasite conservation experiments at Karnal the parasitisation in the conserved plot was 21% before conservation and 35.72% after conservation. In the non-conserved plots the parasitisation was 18.87% and 18.87% for the corresponding periods. In the control the figures were 6.77 and 13.52.

During the year under report 22½ million *Trichogramma* parasites were bred in the parasite laboratory.

Termites and their control.

Five different species, *Cyclotermes obesus, Microtermes anandi, Microcerotermes heimi, Eremotermes paradoxialis,* and *Loptotermes heimi* were recorded from the environs of Delhi. Of these, *Cyclotermes obesus,* in all its three allied forms, was the commonest and was found attacking sugarcane setts, wheat and a number of trees, while *Coptotermes heimi,* recorded for the first time at Delhi, was very rare. Wheat seeds treated with 5% D.D.T. solution or 50% dust before sowing were not attacked. Likewise in plots treated with 1.2% D.D.T. solution prior to sowing this crop there was no attack. Sugarcane setts dipped in 5% D.D.T. solution or in a solution of lead arsenate and lime in water were not attacked ; there was also no attack in plots treated with 0. 24% D D.T. solution.

Insecticides and fumigants.

A 5% solution of dilute acetic acid extract of opium marc tried against certain crop pests in the laboratory gave 30-80% kill, but in the field this was less effective. Opium marc has also been observed to possess strong repellant action on some species.

The maximum mortality of *Bombyx mori* larvae obtained with standard decoction of tobacco leaves was 100% and with that of tobacco stem 86%. In

the case of *Bagrada picta* the maximum mortality was 80% with varieties having 3-3.5% nicotine content, and 46% to 50% mortality with varieties having 1.5-2% of nicotine content.

Predators and parasites.

An internal larval parasite, *Alophora* sp. (?) was recorded for the first time on *Bagrada picta*. Three pupal parasites of *Utetheisa pulchella* were also recorded for the first time. Two of these belonging to the genus Brachymeria were very *common*.

Taxonomic studies of Insect groups of economic importance.

Systematic studies on parasitic Hymenoptera were continued and five new species have been described. The taxonomy of Isoptera was taken up and considerable progress made in the preparation of a catalogue of Indian species.

5. PLANT DISEASES.

Smut diseases of cereals.

Sixty-four varieties of wheat evolved in the Division of Botany were tested during the year under review for resistance to loose smut. For this test two collections made from different localities were used. Forty-nine varieties did not take infection when inoculated with one of these two collections, and forty-eight did not take the infection with the other collection. This work is being continued.

Forty-four wheats from the Central Provinces were inoculated at the Powerkhera Farm, Hoshangabad district (Central Provinces) with isolations made from the C. P. collection of loose smut. The results will be known only in the coming wheat season. Climatic conditions were not favourable for the incidence of wheat loose smut; highly susceptible varieties like Punjab 8-A, C.518, and C.519 were found to be only mildly diseased. The experimental results obtained during this year, therefore, cannot be stressed.

Seed treatment trials against barley covered smut (*Ustilago hordei* (Pers.) Lagerh have shown that the percentage of smutted plants from treated seeds is negligible whereas untreated seed produced 28 per cent. of smutted plants.

The mode of transmission of the long smut (*Tolyposporium ehrenbergii* (Kuhn.) Pat. of jowar was studied with the use of cultures of this fungus but no conclusive results were obtained.

Jowar seeds naturally infected with spores of grain smut *Sphacelotheca sorghi* (Link) Clinton were treated with fungicidal dusts. The controls gave six per cent infection whereas plants from the treated seeds were free from smut.

Pigeon-pea Wilt.

Twenty-two varieties of pigeon pea received from the Imperial Economic Botanist were tested for resistance to wilt (*Fusarium udum Butler*). I.P. 90 and 41 have been found to be resistant in the last three years' trials.

Gram Diseases.

A detailed study of gram diseases has been undertaken. Diseased plants show different symptoms; the object of the study is to see if from the symptoms the specific cause of the disease can be ascertained. Different disease symptoms were noted such as bronzing of leaves, premature shedding of

leaflets, yellowing of the plant from top downwards, complete wilting of the whole plant, wilting confined to a few branches. From diseased plants that showed bronzing the following organisms were isolated: *Rhizoctonia solani, Operculella padwickii, and nematodes.* In some cases no organism was isolated from plants showing bronzing. From plants that showed premature shedding of leaflets nematodes were found infecting the roots. From plants that showed yellowing from top downwards no organism was isolated. From plants that showed complete wilting *Operculella padwickii* and *Fusarium sp.* were isolated. From mature plants having only a few branches that were wholly or partially dead bacteria were isolated from the diseased branches. Bacteria and nematodes have been for the first time isolated from diseased plants. The experiments will be continued on a wider basis in cooperation with other Divisions.

Potato Late Blight.

Naturally-infected potato plants obtained from Kufri were used for testing the resistance of potato hybrids and cultures raised by the Imperial Economic Botanist at Simla. Twenty-two hybrids were found to be resistant and sixty to be susceptible. Varieties 86-D, 126-D, 127-D, 178-D, and 166-D have been found to be resistant during the last three years' trials.

The fungus, *Phytophtora infestans,* has been taken in culture and maintained at Delhi.

Isolations made from diseased tubers from late blight infected plants have given a new *Phytophthora*; this new fungus is under investigation. In the Simla hills there is a rot of potato leaves caused by another *Phytophthora.* This disease appears a little earlier than late blight. This fungus is also being studied

Potato Early Blight.

At Simla two distinct types of early blight symptoms have been observed. In one case the necrotic area was a well marked brown spot with a definite outline; in the other case the diseased area was not sharply delimited from the healthy area; it was "blotchy" in appearance and rather blackish in colour; whether these two types of symptoms are due to different races or strains of the fungus or due to the different varieties of the host requires to be investigated; isolations from these two types of symptoms have been made and there is no morphological difference in the fungus, *Alternaria solani,* isolated from them. Plants raised at Delhi from potato cultures 83 and 256 supplied by the Imperial Economic Botanist from the Potato and Wheat Breeding Sub-station, Simla, were inoculated with these two isolates. The infected leaves showed the blotchy type of the early blight symptom. The same isolates were used for inoculating tomato plants and they produced the blotchy type of infection. Further work on these isolates is in progress.

Tubers of twenty-two varieties were inoculated with *Fusarium solani, Rhizoctonia bataticola,* and *R. solani,* fungi commonly found to cause storage rots of potatoes. Varieties S.80 and S.86 did not take the infection with any of these three fungi; none of the remaining varieties were found susceptible to all these three fungi.

Potato Virus Diseases.

Plants of potato varieties *Darjeeling Red Round, Gola, Up-to-date* and *Phulwa* showing different disease symptoms such as veinal necrosis, cribkle, foliar necrosis, etc., were tested for their virus content with the help of suitable differential hosts. *Solanum viruses I, II* and *III* were invariably found to be present either singly or in mixture with each other. *Solanum virus VI,* a closely related virus to *Solanum virus I,* was recovered for the first time from

potato plants of Phulwa variety. *Solanum virus V* was identified to be the cause of necrotic spots found on the Phulwa variety.

The annual inspection of the potato crops at Kumaon, Chakratta hills and Simla hills was made as usual and the incidence of virus diseases recorded.

A disease showing necrotic rings caused by a virus on tomatoes was observed for the first time during the year under review. Other Virus Diseases.

It was confirmed that melon mosaic virus is seed transmissible.

Of the 24 sugarcane varieties tested for resistance to red-rot at the request of the Government Sugarcane Expert, Co.349, Pansahi and Chunee were found to be fairly resistant. Varietal resistance tests for sugarcane smut were continued. Sugarcane Diseases.

A new rust on *Grewia papulifolia* collected at Rohtak was named *Catenulopsora grewiae* Mundkur. *Cercospora premnae* (Petch.) *scillarum* (Grev.) Winter on Hyacinthus sp., collected at Quetta, are new records for India. As a result of detailed examination, *Uromyces gentilis* Syd. and *Uromyces aulicus* Syd. have been transferred to the genus *Scopella*. A monograph on the rusts of India is under preparation. Taxonomic studies.

The smut collected on Cyperus *difformis* in Kodaikanal was found to be a new species of *Sphacelotheca*, and was named *S. cypericola* Mundkur. *Entyloma compositarum* Farlow on *Lactuca decipiens* collected at Bangalore is a new record for India. The smut of *Alisma reniformis* collected in Mysore was described as *Burrillia alismacearum* Mundkur nov. spec. This genus has not so far been recorded in India. Specimens of smut affected *Cynodon dactylon* collected in Mysore did not agree with those of *Ustilago cynodontis* P. Henn., but agreed with *U. hitchcockiana Zundel;* this is also a new record for India. A monograph on the *Ustilaginales* of India is under preparation.

6. Agricultural Engineering.

The work of this new Division which came into being only in October 1945, was naturally on a very restricted scale.

Research on a small scale was carried out on Wales lifts, country and inverting plough-sub-soilors, etc., and will be continued. Experiments have been in progress to consider the scope of disposal vehicles in regard to their utilization, suitability and actual performance as prime movers in tillage operation and other farm usages.

Experiments were also carried out in the design of a new subsoiler or soil aerator, suitable for bullock draught and the first of these implements is now in course of manufacture.

Work on the modifications of 'Victory' and similar ploughs with regard to improved type of 'hitch' and hand control both suitable for bullock draught with a resultant improvement in performance was also in progress.

III. GENERAL ADMINISTRATION.

Charge :—

Dr. J. N. Mukherjee took over charge of the office of the Director of this Institute on the forenoon of 15th October, 1945. Dr. Mukherjee left for the United Kingdom on 6th June, 1946 to attend the Empire Scientific Conference, in which representatives from the United Kingdom, the Dominions, India and the Colonies took part and returned to India on 6th August, 1946. During this short period Dr. B. P. Pal carried out the current duties of the office of the Director in addition to his own duties as Joint Director.

Dr. B. P. Pal, Imperial Economic Botanist, continued to hold the post of Joint Director throughout the year.

Staff:—

The Divisions of Botany, Agriculture, Mycology and Soil Science and Agricultural Chemistry remained throughout the year under the charge of Dr. B. P. Pal, Mr. C. H. Parr, Mr. J. F. Dastur and Dr. S. V. Desai respectively, the last named holding charge of the Division of Soil Science and Agricultural Chemistry in addition to his duties as Second Agricultural Chemist. The Sugarcane Station, Coimbatore, remained throughout the year under the charge of Mr. N. L. Dutt. A list of the gazetted staff together with such changes as took place in the various Divisions is given in Appendix I.

The following Research Schemes, financed either by the Indian Central Sugarcane Committee or the Indian Council of Agricultural Research as noted against them continued functioning at the Institute :—

(i) Sugarcane Sub-station, Karnal (ii) Scheme for Research on Diseases of Sugarcane (iii) Scheme for Research on Biological Control of Sugarcane Pests. (iv) Scheme for Research on Physiology of Sugarcane	Financed by the Indian Central Sugarcane Committee.
(v) Scheme for Research on Potato Breeding in Northern India. (vi) Wheat Breading Scheme. (vii) Tobacco Breeding Sub-Station, Guntur. (viii) Scheme for Research on Storage of Jowar. (ix) Scheme for the development of Type Culture Fungi-since taken over by Govt. (x) Scheme for the Survey of Icerya purchasi. (xi) Seed Potato Certification Scheme. (xii) Seed Potato Multiplication Scheme. (xiii) Scheme for Research on Storage of pulses. (xiv) Scheme for the Development of certain lines of Research. (xv) Scheme for the Standardization of technique of the fumigation of imported fruits for the control of codling moth.	Financed by the Indian Council of Agricultural Research.

The following new Research Schemes financed by the Indian Central Sugarcane Committee and the Indian Council of Agricultural Research as noted

against each have started functioning at this Institute during the year under report :

(i) Scheme for standardization of technique for the fumigation of imported fruits for the control of codling moth at Quetta. (ii) Scheme for the improvement of maize crop in India. (iii) Scheme for the establishment of a nucleus organization for the introduction of economic plants.	Financed by the Indian Council of Agricultural Research.
(iv) Scheme for Spontaneum Expedition. (v) Scheme for additional staff for the Imperial Sugarcane Breeding Station, Coimbatore.	Financed by the Indian Central Sugarcane Committee.

Training :—

104 Candidates applied for admission to the post-graduate courses begining in October, 1945 of whom 64 were recommended by the Provincial or State authorities. 49 were selected for admission, 7 in Entomology, 6 in Botany, 8 in Mycology, 13 in General Agriculture, 8 in Soil Science and Agricultural Chemistry, 3 in Sugarcane Breeding and 4 in Plant Protection. 9 students completed the post-graduate course during the year and were awarded the Institute Diploma, 3 in Botany, 1 in Agricultural Chemistry, 3 in Mycology and 2 in Sugarcane Breeding. The one-year course in Farm Organization and General Farm Engineering was completed by 9 students. Besides the above, facilities were afforded to a number of short course students and honorary research workers as per details given in Appendix II.

Library :—

The total number of publications received in the Library both on exchange basis and by purchase was 2,244. Over 4,134 books were issued out on loan of which 777 were sent out to the scientific workers in the Provinces and Universities.

498 visitors made use of the Reading Room and consulted 42,107 books during the year.

IV. ACCOUNTS.

The total expenditure of the Institute and its Sub-stations at Karnal, Coimbatore and Pusa during the financial year ended March, 1946 amounted to Rs. 10,93,289.

	Rs.
General expenditure of the Institute including the office of the Director, Irrigation, Power supply, Gas plant and Estate Establishment.	2,67,175
Division of Agriculture	2,40,876
Division of Mycology	59,723
Division of Entomology	74,700
Division of Soil Science and Agricultural Chemistry ...	92,891
Division of Botany	70,873
Statistician	10,152
Division of Agrl. Economics	540
Division of Agrl. Engineering	12,700
Sugarcane Station, Coimbatore	1,04,338
Total Expert Staff and Directorate	9,33,968

B. F. Rs. 9,33,968

Experimental Farms.

	Rs.
Agricultural Sub-station, Karnal	1,29,980
Botanical Sub-station, Pusa	29,341
Total Exprtl. Farms ...	1,59,321
Grand Total of Expenditure	10,93,289

The expenditure of the various research schemes financed by the Indian Council of Agricultural Research and the Indian Central Sugarcane Committee amounted to Rs. 2,16,184 and Rs. 44,264 respectively as shown below :—

Schemes financed by the Indian Council of Agricultural Research.

	Rs.
Scheme for the Development of Certain lines of Research ...	39,063
Potato and Wheat Breeding Sub-station, Simla	49,339
Tobacco Breeding Sub-station, Guntur	25,253
Scheme for Research on Storage of Jowar	4,057
Scheme for the development of Type Culture Fungi ...	165
Icerya Purchasi	14,950
Seed Potato Certification Scheme	12,357
Seed Potato Multiplication Scheme	44,551
Scheme for Research on Storage of Pulses	2,814
Scheme for All India Soil Survey	23,635
	2,16,184

Schemes financed by the Indian Central Sugarcane Committee.

	Rs.
Sugarcane Sub-station, Karnal	11,621
Scheme for Research on Diseases of Sugarcane	5,241
Scheme for Research on Biological Control of Sugarcane pests	20,467
Scheme for Research on Physiology of Sugarcane... ...	6,935
	44,264

The receipts of the Institute and its different Sub-stations amounted to :—

	Rs.
Main Institute	82,048
Sugarcane Sub-station, Coimbatore	9,550
Agricultural Sub-station, Karnal	1,36,212*
Botanical Sub-station, Pusa	2,701
Total Rs.	2,30,511

*Vide Income and Expenditure Accounts reproduced below.

Income and Expentiture Account for the year ended March 1946—

Agricultural Sub-station, Karnal.

INCOME.	Rs.
1. By sale of dairy Produce	50,768
2. By sale of Farm produce	42,878
3. Miscellaneous receipts	847
4. Live-stock	41,719
Total Rs.	136,212

EXPENDITURE.

1.	Pay of officers and establishment...	30,205
2.	Leave salary	3,368
3.	Travelling allowance	317
4.	Dearness allowance	22,963
5.	Feed of Dairy Cattle etc.	13,071
6.	Production of grain and fodder	38,505
7.	Workshop...	2,621
8.	Fuel, light, water etc.	3,796
9.	Miscellaneous contingencies	3,687
10.	Repairs to plant and machinery	10,336
11.	Petty construction and repairs	592
12.	Purchase of Cattle, land and machinery	519
	Total	Rs. 1,29,980

REPORT OF THE DIVISION OF AGRICULTURE

I. AGRONOMY

(a) *DIVISION OF AGRICULTURE, NEW DELHI*

1 *Season and Crops.*—The total rainfall from June 1945 to May 1946 amounted to 26.48 inches, as against 28.68 inches in 1944-45 and 22.08 inches in 1943-44. The monthly precipitations during 1945-46 were as follows :—June —0.73, July—7.28, August— 5.99, September—10.60, October—0.28, November—nil, December—nil, January—nil, February—0.92, March—nil, April—0.02 and May—0.66 inches.

The exceptionally heavy rainfall in September caused damage to standing crops of maize, cotton and sugarcane which lodged badly. This late heavy rainfall, delayed seed bed preparation for the *rabi* crop. By working the new T. D. 9 tractor 16 hours a day in double shifts throughout November, it was possible to complete all sowings without any pre-sowing irrigation. The winter rainfall was exceptionally poor, being 0.92 inches recorded in two showers in February. Even this small rainfall proved beneficial to the standing crops. It checked the rise in temperature thereby preventing early ripening and thus afforded better chances for the grain to develop fully. Ground frost occurred early in December and caused damage to the early pigeonpea crop. One storm in the middle of February caused considerable lodging in wheat barley and oats. *Rabi* threshing operations were hindered by frequent showers in May and frequent breakdown in the machinery which required complete replacement.

2. *Seed Supply.*—The demand for improved seeds from different places was met as usual from the Karnal farm. The total quantity of seed supplied from the Delhi farm was 2,002 lb.

3. *Fodder Supply.*—Sufficient fodder was raised and fed green or preserved as silage and hay for cattle.

4. *Farm Yard Manure.*—Most of the dung and litter is carted straight from the byres to the field. This practice is economical and judged by crop yields appears an efficient method of application.

5. *Work on Sugarcane.*—Eleven new varieties were received from Coimbatore and planted for the multiplication of seed canes. They are growing well and will give enough seed material for the next year's study.

Fifty-four old varieties of sugarcane were grown for the comparative studies, but they were adversely affected by heavy rainfall and wind storms. It was not possible to judge their tonnage yields but according to the chemical analysis, varieties Co. 472, Co. 557, Co K. 30, Co. 602, Co. 604, Co. 611 & Co. 620 were found to be leading as regards sucrose content.

6. *Agronomic Experiments.*—The recent food shortages coupled with the rising trend of population have drawn attention to the urgent need for increased crop production. Measures to bring waste and marginal land under cultivation, to increase water supply for irrigation and power for cultivation and to protect crops against pests and diseases are all receiving attention from the appropriate authorities. The basis of crop yield, however, is soil fertility. Throughout India, the general level of crop yields whether from irrigated or unirrigated land, marginal or old farmed areas are distressingly low. The yields recorded in Agricultural Statistics make this abundantly clear. In an attempt to grow crops to cash in on high prices and to meet the demand for food, Indian soils are being pressed to further stages of depletion. It is this basic problem of

soil fertility which forms the main line of investigation of the field experimental programme of the Agricultural Division, the objects of which are to elucidate its essentials, how it can be built up and maintained under different systems of cropping and what is necessary to enable a cultivator to farm on a rising plane of fertility instead of a low or at best, a declining one.

The more important results obtained from the various experiments in progress at Delhi and Karnal during the year 1945-46 are summarised below.

(I) Nitrogenous Manuring Experiments

(i) *Comparison in field experiments of the relative values of nitrogen in green manures, farm yard manure, compost, oil cakes and sulphate of ammonia, estimating the recovery of nitrogen by the crop and of the changes brought about in the soil.*

The old series of this experiment (Russell Experiment No. 1) was again repeated in Middle Block A-2. The manurial treatments continued to be the same as in previous years, but at the suggestion of the II Agricultural Chemist, blocks I, III and V were limed at the rate of 300 lb. slaked lime per acre, while blocks II, IV and VI were not limed. The object of liming was to counteract the alleged adverse effects of the excess of potash in the soil and at the same time to increase the effectiveness of the available minor elements. The results, however, do not justify this assumption. The yields of grain and straw of wheat I. P. 165 obtained are shown in Table I.

Table I

Yields of wheat I. P. 165 from Middle Block A-2 in 1945-46

	Treatment per acre	*Yields in maunds per acre*			
		Grain		*Straw*	
		Limed	*Unlimed*	*Limed*	*Unlimed*
A.	No manure ...	20.30	21.42	36.90	41.23
B.	Farm yard manure 40 lb. N ...	17 46	22.41	35.78	45.19
C.	Activated sludge 40 lb N ...	24.51	24.76	47.05	46.80
D.	Rape cake 40 lb. N	28.48	26.99	49.77	50.02
E.	Farm yard manure 40 lb. N+ superphos. & pot. sulph. 40 lb. P_2O_5 & K_2O respectively ...	17.58	17.46	36.90	37.02
F.	Activated sludge 40 lb. N+ superphos. & pot. sulph. 40 lb. P_2O_5 & K_2O respectively ...	21.67	18.20	45.69	39.74
G.	Rape cake 40 lb. N+superphos. & pot. sulph. 40 lb. P_2O_5 & K_2O respectively ...	24.64	23.40	46.18	46.68
H.	Compost 40 lb. N ...	24.89	18.57	39.99	37.89
I.	Compost 20 lb. N+am. sulph. 20 lb. N+superphos. to make up 40 lb. P_2O_5 ...	21.79	24.14	43.09	47.30
J.	Farm yard manure 20 lb. N+ am. sulph. 20 lb. N + superphos. to make up 40 lb. P_2O_5 ...	23 52	25.50	43.58	48.78
K.	Farm yard manure 80 lb. N ...	25.01	20.90	44.57	46.18
L.	Am. sulph. 40 lb. N+superphos. 40 lb. P_2O_5 +pot. sulph. 40 lb. K_2O ...	29.22	30.58	55.96	53.61
	Critical difference (5 % level) ...	5.90	5.60	8.94	7.56

(ii) *Russell Experiment No. 2* :—The new series was repeated in Main block plots B and C with the difference that castor cake in treatment D was not applied this year, as it could not be procured in time. The outturn shown against this treatment, therefore, represent wheat yields obtained only from the residual effects of castor cake which was applied last year. The yields of grain and straw of wheat I. P. 165 are shown below ; —

Table II.

Yields of wheat I. P. 165 from Main block 9-B and C

Treatment per acre	*Yields in maunds per acre*			
	1944-45		*1945-46*	
	Grain	*Straw*	*Grain*	*Straw*
A. Green manuring with Sunnhemp...	28.12	71.49	20.72	42.73
B. Green manuring with Cowpeas ...	31.19	71.31	20.23	47.14
C. Rape Cake 40 lb. N ...	31.03	71.41	22.43	56.34
D. Castor cake 40 lb. N (applied only in 1944-45) ...	32.29	76.09	20.54	46.02
E. Farm yard manure 40 lb. N ...	33.43	75.10	19.96	45.89
F. Leaf compost 40 lb. N ...	29.08	64.09	20.45	53.02
G. Am. sulphate 40 lb. N ...	26.72	67.94	22.21	65.69
H. No manure (control) ...	27.25	76.99	19.31	45.06
Critical difference at 5 % level...	5.18	18.71	2.51	8.09

The yields of grain obtained in 1945-46 are lower than those of the previous year, due mainly to the effects of the season. In 1944-45 the crop in the ammonium sulphate plots lodged badly and was attacked with rust and the yields were thus adversely affected.

(II) Phosphate Manuring of Legumes and its Residual Effects

This series of experiments has provided very interesting and valuable results, and the range of trials was expanded in order to follow up and clarify further the results obtained and observations already made. The striking effects of phosphate on yields when applied to legumes and in increasing their phosphate and calcium contents as also in developing a stable type of soil fertility for following crops have been well established by the experiments carried out in this Division over the last six years. The results have attracted attention and the last Board of Agriculture recommended that similar work should be taken up by Provincial and State Departments of Agriculture.

(i) *Berseem Manurial Experiment No. 1.*—As detailed in previous Annual Reports, phosphates and other manures were applied to berseem in Top Block 1 for three years consecutively. In the plots treated with superphosphate alone or in combination with farm yard manure, luxuriant growth of this fodder crop was secured, the yields were doubled and the phosphate content of the crop trebled and even quadrupled in some treatments. Cowpeas were rotated with berseem every *kharif*. After this period, wheat has been grown continuously for the last three *rabi* seasons, without the application of any further manures. A high level of fertility appears to have been built up in the plots manured with superphosphate for berseem as was evident from the heavy yields of wheat obtained subsequently.

(ii) *Berseem Manurial Experiment No. 2 with smaller doses of phosphates.*—This experiment was started in 1941-42 with much lower doses of phosphates than were used in Experiment No. 1 reported above. Berseem was manured continuously for three years. Wheat grown for the last two years on the residual effects of the manured berseem and unmanured cowpeas in the rotation, show clear and definite responses to the higher doses of phosphate manures. In the unmanured cowpeas, following berseem manured every year, similar responses are, however, not evident. For the same amount of phosphate, superphosphate has generally shown higher crop yields than farm yard manure, though the differences in yields are not statistically significant in all cases. In the case of wheat, significant increases in yield over that of the 'No manure' control were obtained whenever the dose of phosphate was 64 lb. P_2O_5 per acre, either in the form of superphosphate or as superphosphate in combination with farm yard manure. This suggests that a dose of at least 64 lb P_2O_5 or about 2 maunds of concentrated superphosphate per acre represents the basic level of phosphate requirement of the berseem crop in the soil of the Delhi Farm. Even at this dose, the yields of berseem showed a tendency to decline during the three-year period of this experiment, although the yields of cowpeas remained fairly uniform. It would appear that the berseem crop was depleting soil phosphate and that 64 lb. P_2O_5 per acre per annum was not adequate. The necessity of a high initial basic dressing of phosphate is thus indicated.

(iii) *Availability of phosphate in composted and non-composted ground bone-meal.*—In 1944-45 the highest yield of berseem (485 maunds per acre) was obtained from the treatment in which bone-meal at 120 lb. P_2O_5 was composted with Baluchistan sulphur. Bone-meal alone at this dose gave 349 maunds while the 'No manure' control treatment gave 344 maunds of green berseem per acre. When this crop was followed by maize in the *kharif* season of 1945-46 the treatments gave yields of green fodder of 309, 275 and 288 maunds respectively. In 1945-46 berseem was again grown in the same field and superphosphate and potash, ammonium sulphate, and ammonium sulphate plus potash etc, were superimposed on the bone-meal treatment, but no differential response to the manures was obtained. The yields in the various manurial treatments ranged from 252 to 346 maunds of green berseem per acre.

(iv) *Efficiency of different forms of phosphates applied to berseem alone and in combination with other manures.*—This experiment was repeated and the yields obtained in 1944-45 and 1945-46 are tabulated below. The ammonium phosphate, superphosphate, charred and ground bone-meal and basic slag were applied at 120 lb. P_2O_5 per acre.

Table III

Yields of berseem from phosphate manured plots with and without other basal manures M. B. 8-E

Basal manurial treatments per acre	Average yield of green berseem in maunds per acre									
	No fertiliser		Ammon. phos.		Superphos.		Bone-meal		Basic slag	
	1944-45	1945-46	1944-45	1945-46	1944-45	1945-46	1944-45	1945-46	1944-45	1945-46
No basic manure	246	431	348	552	262	491	254	415	252	467
Farm yard manure at 120 lb. P_2O_5	309	489	443	548	242	509	358	496	317	512
Green manuring with sunnhemp	244	394	479	551	320	469	308	436	229	473
Sulphate of potash at 50 lb. K_2O	265	416	377	570	317	507	304	458	283	487

It may be pointed out that superphosphate and basic slag were applied in 1944-45 about 6 weeks after sowing berseem, due to their late receipt, and hence their effects on the yields of berseem was not very marked. In 1945-46 all the manures and fertilisers were applied just before sowing the crop. In general, the yields of berseem in all treatments, including the 'no fertilisers' treatment, are higher in 1945-46 than in the previous year.

(v) *Phosphate manuring of berseem with and without basic manuring with farm yard manure or green manure.*—Experiments Nos. (i) and (ii) detailed above, show the fertilizing effects on wheat of phosphate manured berseem grown in three successive years. In practice, berseem is not usually grown on the same field continuously for 3 years. In a new series of experiments started in 1944-45 and 1945-46 berseem was manured with bone-meal, superphosphate, ammonium phosphate etc. and grown for one year only included basal dressing (1) green manuring with sunnhemp grown *in situ* (2) farm yard manure and (3) 'No basic manure'. The berseem crop was followed by maize or fallow—wheat.

The yields show the need for manuring legumes like berseem particularly with phosphates in order to enable the crop to exhibit its maximum potential. Berseem in plot 8-C, without any basic manuring, has given a yield of 140 maunds per acre from "no manure" treatment. The maximum yield of berseem, however, is from the ammonium phosphate treatment, where 263 maunds per acre were obtained. In plot 13-F, which was green manured with sunnhemp, a yield of 188 maunds was secured from the 'no fertiliser' treatment. Again the maximum yield of 316 maunds per acre was obtained with ammonium phosphate. On the other hand, the yields of berseem from plot 7-F, in which raw farm yard manure at 10 tons per acre was applied was 387 maunds, without any further phosphate manuring, but increased to 528 maunds with the addition of ammonium phosphate. Yields of the succeeding crops of maize and wheat were high in plots which were not affected by lodging. The highest yields were generally recorded in plots in which the previous crop of berseem was given phosphate manures,

although the differential response to the manures has in certain plots been masked by extensive lodging due to the high status of soil fertility accruing from the treatment given.

A similar experiment was repeated in adjacent plots in M. B. 16 D, E and F in which the same trend of yields of berseem were again obtained. In 1945-46 an additional treatment with bone superphosphate manufactured by the Delhi Cloth Mills was also included This treatment has given good response and the yields of berseem were only slightly lower than those obtained from triple superphosphate applied at a dose of 120 lbs. P_2O_5 per acre. Bone-super appears to be definitely superior to bone-meal alone and more so in fields 16-E and 16-D where the initial soil fertility status was low.

(vi) *Direct and indirect manuring of wheat and berseem.*—These experiments were started in observation plots in 1944-45. Berseem was grown in Top Block plot 1-A in 1944-45 and was followed by wheat in 1945-46. In plot 1-B wheat C. 518 was grown in 1944-45 and was succeeded by berseem in 1945-46.

In 1944-45 berseem had shown a good response to phosphate alone or in combination with nitrogen and potash, there being no statistically significant responses, however, between the effects of the fertilisers. In 1945-46, the highest yields of berseem have been obtained in the series *'berseem manured after wheat manured'* followed by the series *'berseem manured after wheat unmanured'* and the lowest from the series *'berseem unmanured after wheat manured'*. Maximum yields in the first two series were obtained from the treatments in which superphosphate at 32 lb. was applied to berseem and sulphate of ammonia plus sulphate of potash at 40 lb. N and 40 lb. K_2O have been applied to wheat. In the third series, *'berseem unmanured after wheat manured'* the yields are low. Superphosphate at 66 lb. and N. P. K. have also given very high yield of berseem. In general, the yield of berseem as well as of wheat in 1944-45 have been higher than in the previous year.

In another experiment carried out in M. B. 8-B the residual effect of phosphate manuring to one crop of berseem was studied on wheat C. 518 in paired plots, with five replications. The average yield per acre of wheat from the plots in which berseem was not manured was 23.26 maunds, whereas that from the plots where berseem was dressed with superphosphate at 120 lb. P_2O_5 was 27.55 maunds.

(vii) *Direct and indirect manuring of wheat in a cowpea wheat rotation.*—Previous experiments have shown that as far as yields were concerned cowpeas have not responded to direct manuring of phosphate or to the residual effects of phosphate after berseem, but the crop of wheat following the phosphate manured cowpeas always tended to produce increased yields. It was evident, therefore, that although the yields of the cowpea crop were not affected by phosphate manuring certain definite changes were taking place in its mineral composition as well as in the metabolism of the plant. These changes were responsible from increased nitrogen fixation in the soil and ultimately in the production of higher yields in the succeeding crop of wheat. In 1944-45 superphosphate at 60, 132 and 183 lb. P_2O_5 per acre, with or without farm yard manure at 40 or 80 lb. P_2O_5 per acre were used for manuring wheat. To examine the effect of a higher dose of phosphate the doses of superphosphate were trebled in one half of each of phosphate plots, but even this large increase did not show any significant difference in the yields of cowpeas. This experiment confirms the previous findings that cowpea does not show the same growth response to phosphate as berseem and that legumes vary considerably in this respect. Further evidence on this point is provided by the experiments reported below.

(viii) *Effects of phosphate, potash and lime applied to different kharif legumes on the yields of the following crop of wheat.*—This experiment was carried out in M. B. 1-D with sunnhemp, soybean, cowpeas, groundnut, *guar*, *mung*, *urid*, indigo and an American variety of beans, Manurial treatments included P, Ca, P+Ca, P+K and P+K+Ca. The growth of indigo, groundnut and the bean crops was not satisfactory. In the other crops the differential response to the manures was not significant, although P alone or in combination with K tended to give somewhat higher yields. When these crops were followed by wheat in the next *rabi* without any further manuring higher yields of wheat were obtained wherever P or P+K have been applied to the legume. On the other hand, lime applied alone or in combination with P or P+K depressed the yields of wheat in all cases, excepting those following *mung* and *urid*, in which cases the yields of wheat were comparatively high. The reaction of these two legumes to lime is being investigated further.

(ix) *Effects of phosphate, potash and lime on the yields of certain winter legumes.*—This experiment was laid out in M. B. 1-D with fodder crops, such as berseem, lucerne, *methra*, *senji* and *shaftal* and pulse grain crops peas, gram and *khesari*. All the fodder crops reacted to the phosphate, producing the highest yield from the ammonium phosphate treatment at 120 lb. P_2O_5 per acre, followed closely by the superphosphate treatment at the same dose. The addition of potash slightly depressed the yields, but lime at 10 maunds per acre showed a significant depression. Gram and pea, showed the same trends, but peas gave the highest yields with superphosphate at 120 lb. P_2O_5 + pot. sulph. at 80 lb K_2O per acre. *Khesari* did not show any differential response to the fertilisers. These crops have been followed by maize in the 1946 *kharif*.

The reasons why the winter legumes tested so far show clear quantitative responses to phosphate manuring and why in the case of the *kharif* legumes the responses are qualitative rather than quantitative are problems which need investigation.

Responses similar to those reported above were obtained with a similar series of winter fodder legumes and pulse crops in Main block 1-A.

(x) *Effect of phosphate and potash manuring on gram in relation to wilt disease incidence.*—Wilt is a menace to the gram crop at Delhi. Sometimes 80 per cent or more of the crop is wiped out either by early and/or late wilt. A preliminary experiment was started in 1945-46 to study the effect of superphosphate or sulphate of potash or a combination of these two fertilisers on the crop both in regard to yield and resistance to wilt. Gram types I. P. 25 and I. P. 58 were tried, but the crop was sown late in the middle of November 1945. Yields were good and the incidence of wilt was very low in all the treatments. No differential response of the fertilisers was noticed. As late sown gram has in previous experiments been found to be less affected by wilt it is proposed to repeat the experiment and to fix the sowing date in the last week of September or the beginning of October, which is the usual sowing season for the crop in this area.

(III) Other Manurial Experiments

(i) *Manurial value of ammonium nitrate alone and containing certain percentages of T.N.T. compared with sulphate of ammonia.*—These experiments were started at the suggestion of the War Department of the Government of India in 1944-45 and repeated in the following year to assess the manurial value of ammonium nitrate alone and in combination with small percentages of T.N.T. Large quantities of this war material were expected to be available after the war and investigations as to its manurial value were considered desirable.

The yield of wheat in the 'No manure' treatment in 1944-45 was higher than those in the manured plots because the crop stood up well and was not affected by rust, whereas the crop in the manured plots lodged badly and was affected by rust. No differential responses of the fertilisers used were observed in the case of paddy, sugarcane and cotton, but significantly higher yields were obtained in sorghum and wheat. Between the yields from the standard fertiliser sulphate of ammonia and from the treatments of ammonium nitrate alone or its mixtures with 1, 2 and 3 per cent T.N.T. there were no significant differences, indicating that these fertilisers were as efficient in their response as sulphate of ammonia. No deleterious effects to crops were observed by the introduction of T.N.T. at different percentages.

AMATOL.—A small sample of Amatol was also received from the War Department. This contains about 20 per cent T.N.T. and is highly explosive. Its manurial value was tested against other artificial fertilisers on the yields of wheat.

An increase of nearly 8 maunds per acre over the 'no manure' yield of nearly 28 maunds per acre was obtained from the Amatol treatment, showing the value of Amatol as a fertiliser for wheat.

(ii) *Confounded experiment to test the effect of N, P, K, and Ca, each applied at 3 levels on the yield of wheat.*—This experiment was laid out in a quasi-Latin square with two replications in a 3^4 design, partially confounding the three-factor interactions. Nitrogen was applied in the form of sulphate of ammonia at 0, 40 and 80 lb. nitrogen per acre. Superphosphate was applied to supply 0, 80 and 160 lb. P_2O_5 per acre ; sulphate of potash was applied to supply 0, 80 and 160 lb. K_2O and lime was applied at 0, 5, 10 maunds per acre. Wheat C. 518 was grown as a test crop after a *kharif* fallow. The object of this experiment was—

(*a*) to supplement the data obtained in the Russell experiment,

(*b*) to see the effect of nitrogen, phosphate, potash and lime at different doses, applied alone and in various combinations,

and (*c*) to demonstrate the method of layout of a complex, confounded experiment to post-graduate students under training.

There was heavy lodging of the crop, specially in the plots treated with sulphate of ammonia at high doses, and consequently the results obtained were not quite in conformity with the doses of the fertilisers applied. With the increasing doses of nitrogen, the yields showed a downward trend and the differences between these yields were statistically significant. The differences between the different levels of P_2O_5, K_2O, CaO were not significant. The 2-, 3-, 4-factor interactions were also not significant.

(iii) *The manurial value of Oklanite, digested sludge and activated sludge.*—These experiments were started in 1944-45 on instructions received from the Government of India. Oklanite and digested sludge were supplied by the Joint Sewage Disposal Work, Kilokri, Delhi. The activated sludge was prepared in the Institute plant. The manures were applied at the rate of 80 lb. P_2O_5 per acre and tested against superphosphate at the same dose in the case of peas and with sulphate of ammonia at 80 lb. nitrogen per acre in the case of barley and wheat. A 'No manure' control was kept in all cases.

Wheat and barley have shown definite responses to all the sludge manures. In 1944-45 peas showed a low yield in all the manurial treatments, but in the following year the yields were much higher, though not statistically significant. The data, however, indicate that all the three sludges have high manurial values

and compare favourably with standard fertilisers such as sulphate of ammonia and superphosphate.

(IV) Green Manuring Experiments

As a means of supplementing the inadequate supply of organic manures, the possibilities of green manuring call for examination. Under suitable conditions of soil moisture, proper interval between the time of burying the green manure crops and sowing the next crop etc. green manuring can effectively increase yields and maintain the productivity of the soil. Green manuring for the *rabi* crop has however given very variable results; although a large number of experiments has been carried out in different parts of India an infallible technique has not yet been worked out. The effect on the following crop depends on the amount of available nitrogen at the disposal of the following crop during its early stages of growth. An attempt is being made to work out a green manuring and fertiliser technique which will ensure the presence of the required plant nutrients and at the same time utilise the organic matter supplied by the green manure.

(i) *Effect of fertilisers applied in fields green manured with sunnhemp and cowpeas on the yields of wheat.*—To examine the effects of added fertilisers on wheat green manured with (*a*) sunnhemp and (*b*) cowpeas a new experiment was laid out in 1945-46 in Top Block 4-A and 4-B with different fertilisers applied at the time of burying green manuring crops.

The yields of wheat were very high, ranging from 32.7 to 35.5 maunds per acre in the field which was green manured with sunnhemp and from 28.0 to 38.2 maunds per acre in the field which was green manured with cowpeas, but no statistically significant differences were observed amongst the various treatments.

(ii) *Green manuring experiment with sunnhemp grown in situ or brought from outside.*—This experiment was started in 1945-46 at the instance of the Department of Agriculture, Government of India to see whether sunnhemp grown in another field such as on the waste land on either side of the railways and incorporated in the fields of the cultivator direct or after composting would prove as effective for green manuring purposes as that grown *in situ* or that used as an artificial mulch. Wheat C.518 was used as the test crop.

Due to the high status of soil fertility as evidenced by the yield of 28.5 maunds per acre from the control plot there are no significant differences between the yields in the different treatments.

(iii) *Effects of green manuring and/or mulching with sunnhemp on the yields of different rabi crops grown with one flooding only in September, but without further irrigations.*—This experiment has been carried out with wheat and barley for two years and with three types of peas in 1945-46 only. The monsoon rains from June to September were heavy in both the years amounting to 24.4 inches in 1944-45 and 24.6 inches in 1945-46 whereas the winter rain amounted to 3.78 inches in 1944-45 and only 1.22 inches in 1945-46. With a flooding of about 6 inches of irrigation water in September, the yields were higher in 1945-46 than in the previous year as will be seen from the following table :—

Table IV

Yields of crops with one flooding in September in M. B. 11-E

Crop	Year	*Yields in maunds per acre* Green manured with sunn-hemp	Sunn-hemp grown in situ & mulched upto sowing time	Sunnhemp grown in situ and mulched upto harvest time	Fallow in kharif and mulched with S. hemp after flooding upto harvest time	Fallow in kharif and not mulched
Wheat	1944 45	17.4	18.3	15.8	28.0	25.7
	1945-46	27.6	26.3	27.3	35.5	21.8
Barley	1944-45	21.3	32.1	24.9	42.4	29.4
	1945-46	35.1	39.1	43.5	60.0	34.3
Peas I. P. 15	1945-46	16.3	13.7	18.2	16.9	19.9
Peas I. P. 29	1945-46	14.1	14.6	17.6	14.3	17.5
Peas I. P. 16	1945-46	19.6	17.7	23.6	20.1	24.4

In most cases green manuring has not been as advantageous as fallowing in the *kharif* season. Mulching especially upto the harvest time on the other hand has been more effective than green manuring. In the case of wheat and barley, mulching the fallow land upto harvest time has given the highest outturn, but in the case of peas this is not so effective.

(V) Flood Water Farming Experiments.

These experiments were again repeated both at Delhi and Karnal. The results obtained in each year, commencing from 1941-42 are summarized below:—

Table V

Monsoon and winter rainfalls and yields of crops at Karnal aud New Delhi under flooded and rainfed conditions

Locality	Year	Rainfall in inches: Monsoon (June to Sept.)	Winter (Oct. to March)	Series	Average yield of grain in maunds per acre: Wheat	Barley	Gram
Karnal	1941-42	16·74	7·52	Flooded	14·98	21·66	17·95
				Rainfed	4·44	6·71	0·05
	1942-43	32·71	2·43	Flooded	12·14	17·52	12·03
				Rainfed	13·83	16·60	16·00
	1943-44	17·49	3·21	Flooded	12·77	28·65	19·23
				Rainfed	5·71	17·56	12·57
	1944-45	18·23	2.48	Flooded	10·36	17·67	18·67
				Rainfed	10·22	14·84	17·87
	1945-46	30·13	1·45	Flooded	14·92	13·94	35·48
				Rainfed	18·66	18.81	26·91
New Delhi	1941-42	10·93	2·89	Flooded / Rainfed	Crops destroyed by hailstorm		
	1942-43	26·91	0·87	Flooded	8·88	26·33	10·27
				Rainfed	10·57	18·74	12·23
	1943-44	15·26	5·45	Flooded	3·98	11·01	7·73
				Rainfed	0·99	8·14	1·06
	1944-45	24·37	3·78	Flooded	21·10	30·50	9·87
				Rainfed	20·30	46·40	12·02
	1945-46	24·60	1·20	Flooded	27·45	29·81	{23·93
				Rainfed	25·88	24·39	* {14·50

*(Total yields of mixture of gram, barley, linseed and *sarson*.)

Increases in yield in wheat, barley and gram have been obtained in the flooded series whenever the monsoon precipitations were in defect, but when the monsoon rains were high, as in 1942-43, 1944-45 and 1945-46 the yields in the flooded series are either lower than those in the rainfed series or the differences in yields between these two series are of a lower order. In years of low monsoon rainfall these differences are considerable. This difference decreases as the monsoon rainfall increases, but flooding ensures average yield in all years.

Too much water applied in September causes the soil nitrates to be washed down deep in the soil and thus leads to a temporary reduction in soil fertility in the root-zone, which may not be recovered by subsequent cultivation owing to the falling temperature and reduced activity of the soil nitrifying organisms at this time of the year. This has an adverse effect on early crop growth and shows itself, particularly in wheat, by distinct yellowing of the crop in December. It would appear that this difficulty may be overcome and the basic requirements of moisture met, if flooding is distributed throughout the monsoon by irrigating once a month, in July, August and September, to imitate as far as possible, the optimum conditions of a well-distributed monsoon. If the rainfall in the intervals between irrigations is light, cultivation can proceed to provide the optimum conditions required for nitrification. A crop can make the maximum use of stored water only when adequate supplies of nitrate are present. The adverse effect of heavy September irrigations on the nitrate supply, may be the cause of the smaller differences between the yields of the flooded and rainfed plots in the experiments in years of good monsoon. The check this causes to early growth is not counterbalanced by the greater supply of water in the plot. The more water, whether as rain or as irrigation water, the deeper and more thorough should be the cultivation and seed bed preparation.

Possibilities of increased oil seed production. —The production of oilseeds in India is much below requirements. There seem considerable possibilities of increasing production by flood water farming and experiments to this end are in progress since the last two years.

Although the monsoon rainfall was fairly high in both the years, the differences in yields between the flooded and rainfed crops are in favour of the former in most cases. The Brassicae group of oil seeds germinate well and thrive at higher temperatures than those tolerated by the *rabi* cereals, wheat, barley, etc. They can, therefore, be sown with success in September, and early October before the necessary moisture for germination in the surface soil or seeding zone has been very much reduced by evaporation. This fits these oilseed crops admirably for this type of farming.

(VI) Ley Farming or Alternate Husbandry

In many countries much attention has been given to the development of this system of farming in recent years. In Alternate Husbandry grasses are used either alone or in combination with legumes in leys of 2 or 3 or more years' duration under suitable fertiliser treatments for the production of protein rich fodder and for the accumulation of soil fertility for succeeding food and commercial crops.

A beginning has been made at Delhi with Rhodes grass in a lucerne and berseem mixture during 1945-46 under different fertiliser treatments.

The nitrogenous fertilisers are applied to the Rhodes grass which grows during the summer and phosphate to the legume, which gives a further crop in the winter. Two crops are thus obtained in the course of one year.

The Rhodes grass was planted out in a field which had been under lucerne

continuously for four years. In the control plots the average yield of green grass per acre was nearly 326 maunds. A direct response is seen wherever nitrogen has been applied, but there is no response to P or K in the absence of N. The highest yield of nearly 513 maunds has been obtained from the ammonium phosphate treatment and the second best from the sulphate of ammonia treatment.

The yields of the lucerne-berseem mixture are rather low, but unlike the grass there is no response to nitrogen, but a definite one to P either alone or in combination with P or P+K. The experiment is being continued.

(*b*). *AGRICULTURAL SUBSTATION, KARNAL*

1. *Area*—The area under this farm is 2,154 acres as detailed below :—

Rented for cultivation	202.00	acres
Direct cultivation	1125.53	„
Under *Batai* cultivation	246.78	„
Under Potato Seed Production Scheme ...	26.20	„
Usar land	35.00	„
Sugarcane Substation	24.00	„
Area under roads and buildings ...	212.00	„
Area leased out for grazing	143.50	„
Pasture land for grazing Tharparkar herd etc.	138.99	„
Total	2154.00	„

During *rabi* 1945-46 another area of 27.42 acres reverted from the area under cultivation to the Sugarcane Substation thus increasing the area to 51.42 acres in the *rabi* against 24 acres in the *kharif*.

2. *Season and crop*.—The rainfall during the year though ample in amount was not well-distributed. Heavy and continuous rain during August and September hampered tillage operations and adversely affected the standing *kharif* crop, but enabled a greater area of *barani rabi* crops to be sown on the moisture thus provided. The dry winter, with only late and light showers in February adversely affected the *barani rabi* cereals. The humid summer with about 2.64 inches of rain during April and May caused frequent interruptions and delays in harvesting and threshing of *rabi* crops, which resulted in some loss of grain and reduction in yield due to shedding.

3. *Cultivation*.—Only one tractor was in work throughout the year, the others having reached the end of their working lives. The strength of bullocks was further reduced to 61, of which only 40 are available for cultivation, as the remainder are regularly employed in routine transport and other duties. Adequate cultivation is no longer possible with this equipment. Since the area which can be manured is limited by the number of cattle kept, yields must depend on effective tillage. If this too is absent, yields must decline. The practice of giving land on '*batai*' (share system) which has been in abeyance since 1936 has had to be again adopted owing to lack of machinery and equipment necessary for direct cultivation. If early improvement in this respect is not made, the *batai* area will have to be increased.

4. *Irrigation*.—The supply of irrigation water to the farm is insufficient. The two tube wells sanctioned in 1941 could not be installed. Tube wells will enable the new system of cropping and manuring to be adopted which has proved very successful at Delhi and will ensure the building up of soil fertility and a great improvement in crop yield.

5. *Funds*.—The budget provision is quite out of proportion to the needs of the Farm. Even with the curtailment of the area under direct cultivation,

the expenditure per acre including both *rabi* and *kharif* and all direct and indirect charges on crops amounts to only Rs. 46 per acre. Such an allotment is hopelessly inadequate, particularly when this has also to cover a large number of important experiments. At present prices of labour, the work cannot be carried out thoroughly and properly at less than Rs. 200 per acre, which is about the figure at which experimental farms in the Punjab are financed.

6. *Machinery.*—One new track-type tractor, T. D. 14 was purchased in July, 1945. There was no improvement in the coal situation and hence the Fowler Steam Tackle could not be worked on any large scale. One W. D. 40 tractor No. 1612 became unserviceable after completing more than 8000 hours' work, which is its ordinary period of life. The cost of working this tractor comes to Rs. 2.16 per hour.

McCormick Deering diesel tractor No. 9962 worked for 866.7 hours during the year, but remained out of order from July to October for want of spares. The cost of working this tractor during the year was Rs. 4.07 per hour.

Lanz Bull-Dog tractor 15/30 H. P. was kept in operation, but used for light work only. The total hours worked during the year by this Tractor were 706 75 and the cost per hour was Rs. 2.32.

The now track-type tractor T. D. 14 worked satisfactorily for 900 hours, after which there was loss of power due to the wear of piston rings and to fuel pump trouble. In all it worked 1104 hours during the year.

7. *Harvester.*—Only two bullock drawn reapers could be worked during the year but due to lack of spare parts they did not work satisfactorily.

8. *Thresher.*—The two Marshall threshers did not work well, as many parts require immediate renewal but are not available.

9. *Ensilage cutter.*—Only one chopper G. 3 which is very old and in need of constant repairs was in work.

10. *Implements.*—The condition of farm implements went from bad to worse as no replacements of worn parts were possible. Steel, for making shares for bullock ploughs even could not be obtained. New implements are also not available and the full power of the new tractor could not be fully utilized for want of suitable implements to work with it. The need for at least two good harevester threshers and three tractors and new sets of implements is undeniable.

11. *Cropping plan.*—In spite of serious difficulty with regard to equipment, funds and labour, the experimental programme was greatly extended. Reasonably good yields, considering the large areas handled were obtained as shown below: —

Crop	Area (acres)	Yield per acre (maunds)
Paddy	64	27.5
Wheat	80	20
Oats	120	20
Gram	135	18

When the tube wells are installed and water for irrigation assured, the staff strengthened, funds and equipment provided proportional to the needs of the farm, there is no reason why high average yields cannot be obtained. The adoption of a systematic cropping programme based on the result of the fertility experiment carried out at Delhi and Karnal during the last 4 or 5 years will ensure not only high yields, but a gradually rising plane of soil fertility and will provide a convincing practical demonstration of the possibilities of increasing

crop yields by methods of soil fertility improvement which any cultivator can employ in areas where a good system of irrigation obtains.

12. *Agronomic Experiments.*—The results of the more important experiments carried out during the years are given belows :—

(I) Direct and Indirect Manuring of Paddy in Different Rotations

(i) *Paddy-Wheat rotation.*—After a crop of berseem, paddy was grown in *kharif* and was followed by wheat in the *rabi* 1945-46. The manurial treatments were given to each of the two crops once to paddy in the *kharif* and to wheat in the *rabi*.

The beneficial effects of the previous crop of berseem on the yields of paddy are reflected in the high yield of 27.6 maunds per acre obtained from the 'No manure' control plots. Sulphate of ammonia at 80 lbs nitrogen produced the highest yield of 29.7 maunds per acre. The phosphate manures with and without nitrogen have not shown any increase in yields. In the case of wheat, the highest yield was obtained from the ammonium phosphate treatment. Ammonium sulphate alone or in combination with phosphate has given increases of 5 to 7 maunds per acre over the control yield. Superphosphate and bonemeal have shown lower yield than the control plot although the differences are not statistically significant, which is in line with general experience that phosphates are ineffective in these soils when applied to cereals direct.

(ii) *Paddy-legume rotations.*—These experiments were started in the *rabi* season of 1944-45.

In the paddy-berseem rotation, the yields of berseem in 1944-45 and in 1945-46 were similar in the various manurial treatments excepting in treatment with ammonium sulphate at 40 lb. N in 1945-46, yield of which is beginning to show the depressing effect of ammonium sulphate on the berseem yield. The yields in all the manurial treatments are higher than those in the 'no manure' treatments. The paddy crop taken in between these two crops of berseem has given high yields in all treatments. The 'no manure' control plot has yielded 26.6 maunds per acre. Ammonium sulphate at 40 lb. nitrogen applied to paddy has given the highest yield of 31.8 maunds. The yields from the superphosphate treatment applied to berseem and sulphate of ammonia at 40 lb N applied to paddy has yielded 30.4 maunds of paddy per acre. Ammonium phosphate applied to berseem with no other fertiliser to paddy has produced 31.2 maunds of paddy per acre.

In the paddy-pea rotation peas were grown only in 1945-46 and the yields showed very little differences excepting in treatment with ammonium phosphate to paddy and ammonium phosphate and bonemeal to peas. In the case of paddy, ammonium sulphate alone or in combination with phosphate has increased the outturn.

In the paddy-gram rotation the yields of gram was much higher in 1944-45 than in 1945-46, but no significant differences are observable amongst the various manurial treatments. The yields of paddy are lower than those in the other two rotations, but have showed significantly higher yields in the treatments where phosphates were applied to the gram and ammonium sulphate to the paddy. Ammonium phosphate when added to gram has produced the best yield of paddy.

In general the yields of paddy are higher in paddy-berseem and paddy-pea rotations than in a fallow-paddy rotation indicating the value of a suitable legume in the rotation. Paddy after berseem has shown the highest yields. The bone-

meal treatment and the ammonium sulphate + superphosphate treatments show a tendency to depress yields whereas the other treatments show significantly higher yields than the control.

(iii) *Paddy manurial experiment in rotation with berseem.*—The effects of different manures and fertilisers on the yield of paddy and their residual effects on berseem without any further manuring are being studied in this experiment.

The yields of paddy, as well as of berseem were extraordinarily high in this field and the differences between the yield in the various treatments are not very significant. Bonemeal at 80 lbs. P_2O_5 per acre appears to have slightly depressed the yields, but at the higher dose and in combination with farm yard manure it has increased the yields. The yield from bonemeal in combination with sulphate of ammonia is also high.

(iv) *Effect of dipping paddy seedlings in night soil and other manures before transplanting* —The Indian Agricultural Mission sent to China a few years ago observed that in certain tracts, the Chinese cultivator dipped the roots of paddy seedlings in a mixture of equal parts of night soil, wood ashes and ordinary soil before planting them out, the underlying idea being to give a good start to the growing seedlings. At the instance of the Government of India, the practice was put under test at Karnal during 1945-46 along with similar treatments with other mixtures. The treated seedlings were planted out in randomized plots with (I) no basic manure and (II) sulphate of ammonia at 2 cwt. per acre.

The crop was planted in a rich soil after berseem. The yields even from the 'No treatment' (control) plots are high. The application of sulphate of ammonia at 2 cwt. per acre has shown no effect. The dipping of seedlings in a solution of night soil, wood ashes and soil has improved the yield by 4.9 maunds and 3.5 maunds in series I and II respectively. The practice appears worth further examination. It may be found possible to replace night soil by mixture to which objection is not raised. The mixtures of farm yard manure and wood ash and of artificial fertilisers have also proved effective but not to the same extent as night soil.

(v) *Cultivation experiment with paddy using tractor ploughs and country ploughs at different periods.*— This experiment was started during the *kharif* season of 1945-46 at the suggestion of the Imperial Council of Agricultural Research and the Government of India but during this season all cultivations were carried out during the usual season only. From 1946-47, cultivations will be carried out as indicated below. The object of the experiment is:

(1) to test tractor cultivation against cultivation with the ordinary bullock drawn ploughs and (2) to ascertain whether tractor cultivation or bullock cultivation immediately after harvesting the rice crop produces a better yield than ploughing at the usual normal time.

The cultivation treatments include :—

TN—Tractor ploughing at the time of cultivation normally carried out for rice.

TH—Tractor ploughing immediately after the rice harvest.

PN—Ploughing with country plough at the time of cultivation normally carried out for rice.

PH—Ploughing with country plough immediately after the rice harvest.

The lay-out consists of randomized blocks with three replications. The total area under the experiment is 15 acres. During the year under report paddy

I. P. 97 gave average yields of 24.7 and 24.4 maunds per acre respectively from the tractor ploughed plots and plots cultivated with the country plough.

(II) Phosphate Manuring of Legumes

As a means of improving soil fertility, phosphate manuring of legumes especially fodder legumes of the *Trifolium* group, offers considerable possibilities. With a view to testing the results obtained at Delhi under Karnal soil conditions a number of experiments with berseem and one with *shaftal* have been started.

(i) *Phosphate manurial experiments with berseem*

(a) The manurial experiment with berseem carried out in plot 4-C.H. confirms the results obtained at Delhi that for the same amount of P_2O_5 ammonium phosphate produces higher yields of green fodder than superphosphate. The low yield of the mixture of superphosphate and farm yard manure at 80 lb. and 40 lb. P_2O_5 respectively is quite contrary to results at Delhi and needs confirmation.

(b) *Effect of different doses of P_2O_5 on yields of berseem.*—That berseem can utitilize efficiently high doses of phosphate and within certain limits responds better to higher and higher doses of this mineral was found from this experiment.

The yields tend to increase with increases in the dose of phosphate applied, but the differences between the yields of the different doses are not statistically significant.

(c) *Phosphate manuring of* shaftal (*Trifolium resupinatum* L.).—This experiment was started this year. Growth was poor and final yield unsatisfactory. The experiment is being repeated.

In this crop also ammonium phosphate at 130 lb. P_2O_5 has given higher yields than superphosphates at the same dose, a result which is similar to that obtained in other experiments with berseem. Liming appears to have depressed the yield.

(III) Green Manuring Experiments

The results of green manuring experiments carried out at Karnal during 1945-46 are summarized below.

(i) *Complex experiment with different green manure crops with and without fertilisers.*—This experiment was started in 1945-46 to study the effects of green manuring with sunn-hemp, indigo, pigeonpeas and a mixture of these three legumes, with and without artificial fertilisers, N, P, N+P, N+P+K, N+K and K. The test crop was wheat C.518. The superphosphate was applied before sowing the green manure crops, but the other fertilisers were put in before sowing wheat. In the case of plots without any green manuring, all the fertilisers, including superphosphate, were applied before sowing wheat.

Under the conditions of these experiments, however, no significant differences between green manuring treatments and the 'no green manure treatment' with and without fertilisers have been obtained during the year.

(ii) *Effect of N, P and K on the growth of green manured and non-green manured wheat.*—This experiment was repeated in half acre plots with wheat

I.P.4. N, P and K have been used in the form of sulphate of ammonia, superphosphate and sulphate of potash respectively.

Although increases have been obtained by the addition of nitrogen alone and somewhat lower yields by the application of phosphate alone, significant increases have been obtained in the N+P and N+P+K treatments in both the series. This confirms the results obtained last year and shows that a complete fertiliser N+P+K or at least N+P gives higher outturns of wheat than when these fertilisers are applied singly after green manuring the field. The effects on the succeeding crop depend on the amount of available nitrogen at the disposal of this crop during its early stages of growth.

(IV) Flood Water Farming Experiments

These experiments were continued as in previous years and the results have been discussed in the Delhi report.

(V) Mixed Farming Experiments

These experiments have been continued, as usual, in holdings of 8, 25 and 400 acres respectively. The results are under examination.

(VI) Tillage *Cum* Manurial Experiment with wheat

This experiment was continued with the object of studying the relative merits of three alternative forms of tillage. The main treatments being (1) power cultivation with tractor ploughs and other tractor-drawn implements, (2) bullock cultivation with soil inversion plough (Victory plough) supplemented with country plough and (3) bullock cultivation without soil inversion by country ploughs. The manurial treatments and the yields obtained are shown below.

Table VI. Yields of wheat C. 518 from tillage cum *manurial experiments in General Block—1945-46*

Field cultivated with	No manure.	F. Y. M. 60 lb. N	Am. sulph. 60 lb N	F. Y. M + Am. sulph. each at 40 lb. N	Average for tillage treatments
Tractor ploughs	11·1	14·3	17·3	19·7	15·6
Victory plough supplemented with country ploughs	15·0	19·5	19·3	20·4	18·5
Country plough only	11·5	19·0	15·1	20·4	16·5
Average for manurial treatments	12·5	17·6	17·2	20·2	Critical difference at 5 % level= 3·9

The most effective cultivation as reflected by yields of wheat obtained, is cultivation with Victory plough supplemented with country plough. Ploughing with non-inversion country plough has resulted in lower yields than those obtained by this method of tillage and the lowest general effect is shown by tractor cultivation. The manuring treatments have shown the best effect when farm yard manure and sulphate of ammonia were used at 40 lbs. nitrogen each. There is little or no difference when these manures are applied singly. All the manurial treatments have produced higher yields than the 'no manure' control.

(VII) *Usar* (Alkali) control

The rotation of paddy with berseem practised in plot No. 7 has been found to be very helpful in keeping a check of *usar* development. The method of covering *usar* patches with artificial mulch in the form of waste farm products or with paddy straw was continued this year and proved very effective in checking the upward movement of alkali salts.

(VIII) Potato Cultivation

25 acres of land was set aside for multiplying virus free certified seed potatoes by the Imperial Mycologist. The staff incharge of the cultivation work was placed under the supervision of the Farm Superintendent. The following varieties were planted:

Variety		Seed rate per acre	Acreage	Av. yield in mds. per acre
Red Round	...	15 maunds	8·5 acres	28·9
Phulwa Patna	...	9 maunds	11·6 acres	127·6
Phulwa Special	...	6·5 maunds	0·8 acres	
Phulwa Bihar Sharif	...	14 maunds	4.1 acres	71·4

The planting was done from 11th to 27th October. The crops were badly damaged by frost during the month of December.

(IX) Experiments carried out for other Divisions of the Institute

These included the following experiments:—

(1) Cotton experiment for population studies of the Spotted Cotton Boll Worm for the Imperial Entomologist.

(2) Sugarcane for Pyrilla control experiment for the Imperial Entomologist.

(3) Trial of linseed cultures for the study of rust resistance for the Imperial Economic Botanist.

II. CATTLE BREEDING

(a) Sahiwal Herd—Division of Agriculture, New Delhi

1. *Herd strength.*—On 1st July 1945 the herd strength was 291 head, and on 30th June 1946 it was 295. For the last few years, due to difficulty in the disposal of male stock for breeding purposes the herd strength has steadily increased to 300 head. There is great demand for cows and they are easily disposed of. The demand for the young male stock however for dairy stock improvement is somewhat poor. The reason lies probably in the comparatively poor draft qualities of the Sahiwals. Efforts are being made to meet this by selection for definite dual purpose, draft and milk type. The success so far achieved indicates that there are hopeful possibilities along these lines.

2. *Health and condition.*—During the year there were two attacks of Foot and Mouth disease and two outbreaks of Haemorrhagic Septicaemia. During the heavy rains of August and September there were several severe cases of 'Three-day fever'. Whilst Foot and Mouth disease caused no mortality in adult stock, it led to serious loss of health and milk yield in the worst affected cases. In certain cases particularly those in advanced pregnancy there is complete inhibition of milk in the immediately following and even in subsequent lactations.

Rough coat, panting, and a tendency to grow fat develop. There appears no satisfactory method of treatment of such cases. In 'three-day fever' there is complete cessation of milk yield during the three day febrile period but after convalesence normal yield is recovered.

Early in the year there were some cases of mineral inbalance among heifers and cows after calving, that is, during the flush period. It was found that this could be adjusted by reducing the number of times of milking from four to two and by increasing the period of special feeding before calving. One of these cases developed Johnes disease and died.

Navel ill was a recurring trouble amongst new born calves usually with respiratory complications (pneumonia) and this was responsible for the high mortality in calves below 2 weeks of age. Respiratory complications did not prove amenable to sulphanilamide treatment.

New born calves are being inoculated with Haemorrhagic Septicaemia serum after birth and later with vaccine as at Karnal.

Cattle were protected against Haemorrhagic Septicaemia and Black Quarter. Five cases of H. S. occurred in inoculated animals.

3. *Milk Yield.*—There was a slight fall in the wet average yield, being 8·7 lb. per cow per day but a high percentage of cows was maintained in milk (70%) and the overall shows less decline being 13·1 lb. for the year under report. Two outbreaks of Foot and Mouth disease interfered with production particularly in cases of cows in the flush period on the yields of which the maintenance of the wet average depends.

Two cows yielded over 10,000 lb., one over 9,000 lb. and six over 8,000 lb. in a lactation period of 305 days. Two heifers yielded over 8,000 lb. four over 7,000 lb. and three over 6,000 lb. in 306 days.

4. *Calf rearing.*—During the year under report, 72 calves were reared out of 89 born. Navel-ill and calf pneumonia account for the death of 11 new born calves. Four young calves died of Foot and Mouth disease. The practice of calf feeding with standardised milk containing 3·5% butter fat was continued.

(b) THARPARKAR HERD—AGRICULTURAL SUBSTATION, KARNAL

1. *Strength of the herd.*—On 1st July, 1945 the herd strength was 308 head and at the end of the year it was 279.

2. *Health and condition.*—On the whole the herd maintained good condition and health throughout the year. One outbreak of Foot and Mouth disease occurred in May, 1945, the effects of which lingered on for some time in the more seriously affected cases. A few of the high milkers suffered considerably. Calves born from affected dams were found below normal in constitution and required greater attention in rearing.

Protective inoculations were carried out as per schedule against Rinderpest in March, Haemorrhagic Septicaemia in July and December and Black Quarter in June. As an experimental measure calves are given Haemorrhagic Septicaemia serum at birth and H. S. vaccine ten days later, in an attempt to minimise calf mortality from pneumonia which appears as a complication with navel ill. It is too early to give an opinion of its value but since the introduction of the practice losses have been very small.

Five bull calves and four cow calves died of calf pneumonia. One cow died of peritonitis as a result of sepsis after calving.

3. *Milk Yield.*—The yield has been maintained at a high standard inspite of the effects of Foot and Mouth disease. The percentages of cows in milk averaged 71% throughout the year and the overall average (wet and dry) is maintained at 15·1 lb. per head per day, the wet average being 21·1 lb. per head per day.

During the year 37 adults and second calves completed lactation. Four of the above were badly affected with Foot and Mouth disease. The remaining 33 gave an average lactation yield of 6849 lb. in 306 days. Three of these gave more than 8,000 lb and seven above 7,000 lb. There were 27 heifers completing lactation. Of these two lactations were short owing to Foot and Mouth disease. In the heifers group seven gave yields over 7,000 lb and ten above 6,000 lb. The average for the 27 heifers is 6732 lb. per lactation.

4. *Calf rearing.*—Out of 77 calves born during the year, 67 were reared. Ten calves died from pneumonia. The rate of growth was normal.

III. RESEARCH PROGRAMME FOR THE YEARS 1946-47 AND 1947-48.

A. Agronomy

A. *Manurial trials*

1. Manurial experiments to determine the relative values of nitrogen in different organic manures and sulphate of ammonia and the estimation of the recovery of nitrogen by the crops and the changes brought about in the soil will be continued in collaboration with the Imperial Agricultural Chemist.

(i) The old series in Middle Block A-2 will be discontinued.

(ii) The new series in Main Block 9-B & C will be continued and

(iii) Another new series on a more comprehensive basis will be started in 1947-48 after the final approval of the scheme by the Indian Council of Agricultural Research.

2. Further development of the results of previous experiments on the phosphate manuring of legumes and their direct and indirect effects on succeeding food and fodder crops.

3. Paddy manurial trials at Karnal including:—

(*i*) the trial with sulphate of ammonia, farm yard manure, bonemeal etc.

(*ii*) Direct and indirect phosphatic manuring of paddy in different rotations, viz., (*a*) paddy-wheat, (*b*) paddy-peas (*c*) paddy-gram and (*d*) paddy-berseem.

4. Effect of dipping paddy seedlings, before transplanting in mixtures of night soil, ash and ordinary soil, as well as, in mixtures with other manures. This experiment will be continued at Karnal.

5. Effect of ammonium nitrate alone and in combination with different percentages of T. N T. on sorghum and wheat at new Delhi and paddy and sugarcane at Karnal.

6. Manurial trials with Oklanite, Digested sludge, Activated sludge etc. with wheat, barley and peas.

7. Manurial trials with certain oil-seeds.

8. Effect of phosphate and potash manuring on gram for controlling wilt disease.

9. Effect of spacing and placing of phosphates on pigeonpeas and of placing manures on different legumes.

10. Direct and indirect manuring of sugarcane in berseem and *senji*—sugarcane rotations.

11. Acclimatization and manurial trials with new imported clovers.

12. Ley farming and manurial trials with grasses, lucerne and other crops.

B. *Green Manurial Experiments*

1. Green manuring experiments with cowpeas, *guar* and *mung* with and without different fertilisers applied to them by placing or broadcasting.

2. Green manuring experiments with indigo, with and without fertilisers.

3. Effect of fertilisers applied to fields green manured with sunnhemp.

C. *Cultural experiments*

1. Tillage experiments at Karnal to test the relative merits of tractor ploughs, bullock drawn iron and wooden ploughs in tillage operations required for the cultivation of wheat.

2. Cultivation experiment at Karnal with paddy conducted with tractor ploughs and country ploughs as suggested by the Government of India.

D. *Mixed Farming Experiments*

1. Continuation of the experiments in holdings of 400, 25 and 8 acres each at Karnal and with an 8-acre holding at New Delhi.

2. Continuation of the experiment in two small holdings at New Delhi with 50 and 66·6 per cent intensities of green manuring.

E. *Mechanized Farming Experiments at Karnal*

These will be continued on the lines followed in previous years.

F. *Flood Water Farming Experiment*

Continuation of the work in progress at New Delhi and Karnal on experimental scale as well as on a 300-acre holding at Karnal.

G. *Mulching Experiments with Sugarcane trash, etc.*

These will be continued on the lines already in progress. The effect of mulch cover in relation to the movement of alkali in soils will also be continued.

H. Collection of Fodder grasses

Maintenance and fresh collection of indigenous and exotic grasses will be continued.

I. *Crop—weather observations*

The correlations of certain agronomic characters of wheat and sorghum with weather factors will be studied.

J. *Experiments of other Divisions of the Institute*

Field experiments will be carried out at the instance and suggestions of other Divisions of the Institute as in previous years.

K. *Cultivation of Seed Potatoes at Karnal for the distribution of disease-free material.*

This work will be continued in collaboration with the Division of Mycology and Plant Pathology.

B. Breeding Herds

A. Handling of Sahiwal and Tharparkar stock for the development of 'milk temperament'.

B. Feeding of stock on a balanced ration for growth, early maturity, high milk production under 4 times milking, based on a narrow ratio of 1 : 3·5 to 1 : 4·0 according to Morrisons feeding standard.

C. Four-times milking as a means of stimulation of high milk yield in Indian milch cattle.

D. Premilking

(*a*) As a means of stimulation for milk secretion.

(*b*) To train heifers to milk before they actually calve.

(*c*) To prevent malformations of the udder.

E. Early maturity treatment

(*a*) To prove milk capacity of heifers before 4 years of age.

(*b*) To test bulls for transmitting capacity of high milk yield before the age of five years.

(*c*) Mating heifers to bulls on a standard size of 2/3rd adult live-weight (600 lb.) irrespective of any age below 2 years.

F. Calf rearing on standardised milk based on a scale 1/10th of birth weight for an even rate of growth, as a measure of control against scouring in calves in the early weeks of their lives, due to a high percentage of butter-fat in the whole milk.

IV. STATISTICAL BRANCH

The whole year under review was devoted almost exclusively to the Statistical examination of the records of the Pusa Pedigree Sahiwal Herd. The records were to be examined from so many aspects that the entire strength of the section had to be switched on the dairy work alone. Whatever work could possibly be finished is given below in a consolidated form.

Statistical Examination of the records of the Pusa Pedigree Sahiwal Herd

The Sahiwal herd was started at Pusa in April, 1904. Thus the data examined form a historical review of about 40 years' breeding work. The foundation stock consisted of one bull and fourteen cows. The original scheme had three objects in its view—to study the effect of removal of a herd from its native tract to another part of India; to constitute the animal side in the development of a system of mixed farming in the Agricultural Division; to supply milk to the large staff at the Indian Agricultural Research Institute.

In April, 1932, four times milking and early maturity experiment was introduced. The weaning of calves of the entire herd was taken up systematically in December, 1918 and by 1919, all the heifers were milking without calves. By 1925, the whole herd was accustomed to the new experiment with the exception of very few old cows.

Amritsari, a stud bull, was used for breeding continuously for about ten years. A few bull calves that came with their mothers were used for short duration as studs. In September, 1913, the cows were divided into a number of groups and by using bulls unrelated to the cows, inbreeding or line breeding was avoided as far as possible. All the bulls selected for breeding were from high milkers. The majority of the bulls has not increased the milk yield of their daughters. In no case did the sire appear to be responsible for increasing the yield of daughters from high milkers. Some of the best bulls were capable of increasing the yield of mediocre cows only. No systematic line breeding or inbreeding was practised. Most of the high yielders came from distantly related parents.

Calf Rearing:—In the beginning all the calves were allowed to suck milk. Consequently either they got too little or too much of milk, with the result that delicate calves started scouring. In 1911, first attempts were made to rear calves away from their mothers. This resulted in more trouble for the calves and in increased mortality. Slowly the position improved with accumulation of experience. Milk was fed at blood temperature Mortality amongst calves below 3 months of age was very high in the years 1919-21, which was about the time when the experiment of weaning the calves was begun. The percentage of deaths under 12 months and above 3 months has been uniformly very low.

Age at first calving:—In the beginning it was about 41 months; later it varied between 44-46 months; subsequently it gradually decreased to 36 months. Since the introduction of 4 times milking in 1932 this was 31.0 ± 0.46 months in the case of starting heifers. Heifers bred in the dairy after 1932 were maturing 5-7 months earlier than before.

Milk yield:—This has been examined in its various aspects. During the period 1914-15 to 1927-28 the annual wet averages vary between 9.4 to 12.2 lb. There has been a slight increase in the yield during the period 1928-29 to 1931-32. The averages fluctuate from 12.5 to 14.6 lb. Since the introduction of four times milking and early maturity experiments, the averages steadily increase from 17.5 lb. to 22.3 lb. till 1937-38. Subsequently the averages vary between 19.0 lb. and 22.0 lb. In most of the years the minimum average is reached somewhere between September and March, mostly in October or November. Monthly averages go on decreasing from April till October or November and then increase.

The variation in the annual overall averages is much less than that for the wet averages. For the years 1914-15 to 1931-32, the overall averages lie between 4.58 lb. and 7.49 lb. After 1932 the overall averages do not show any steady increase from year to year till 1937-38. They fluctuate between 9.23 lb. and 12.82 lb. After 1937-38 the averages are much higher and lie between 12.12 lb. and 15.58 lb. The overall averages reach a minimum somewhere between September and March.

The number and the percentage of cows in milk were very low for the period 1925-26 to 1931-32, the percentage being less than 50 in most of the cases. They were maximum for the period 1939-40 to 1944-45. This has been made possible by reducing the service period. It is in the fourth or fifth lactation that cows generally attain their peak yield.

A better idea of the improvement in yield can be had by comparing the wet and overall averages. Comparing the averages for four times milking with that for two times milking, it has been noticed that increase in the case of heifers as a result of four times milking ranges from 50% to 80%; for adults it is between 60% and 90%.

The differences in the averages whether between lactation or progeny in the case of overall averages are not significant. For the period 1904-32 there is no improvement in the overall averages in any of the lactations of the second and subsequent progeny. Like the wet averages the overall averages for the period subsequent to the introduction of four times milking and early maturity experiments show steady increase from progeny to progeny in the first and second lactations.

Butter-fat analysis :—No butter-fat records were maintained for the period 1904-32. Since 1932 the butter fat-data were collected only for the morning and evening and not for all the four milkings. The examination of the available data leads to the following conclusions :—

(i) The fat percentage is significantly more for the evening milk than that for the morning. The differences between the average fat percentages in different lactations are not significant. The average fat percentage for the morning and evening varies from $4.64 \pm 0.10\%$ to $4.89 \pm 0.11\%$ and $4.86 \pm 0.11\%$ to $5.23 \pm 0.08\%$ respectively.

(ii) The fat percentage increases from week to week in the first three lactations only.

Service period :—There is considerable fluctuation in the service period from progeny to progeny and from lactation to lactation, but there is no systematic reduction in the service period as we pass from generation to generation. The service period is not affected by age. The differences in the service periods whether between lactation or between progeny for the period 1932-42 are not significant.

It has been shown that if a cow is served about 11 weeks after calving it is likely to give the maximum yield in her lactation. Further, it has been found that the life time yield will be maximum, if the service period of a cow is about 7 weeks.

Wet period :—The wet period for the purchased cows is more than ten months for the first four or five lactations. In all the other cases the average is less than ten months or near about. The variation in the wet period during the pre-experimental period is about 15% in the majority of lactations in the different progeny ; whereas it is 30% during the period 1932-42.

Dry period :—The dry period shows considerable fluctuation from lactation to lactation and progeny to progeny. There is no marked reduction in the dry period in the later generations. During the pre-experimental period the average dry period is 200 days or more in the majority of cases. The differences for dry periods, whether between lactations or progeny, are not significant for the period 1932-42, and are much less than that for the pre-experimental period.

Birth weight of calves :—The examination of the birth weight of male and female calves shows that :

(i) The birth weight of male and female calves from heifers vary from 47.97 ± 1.22 lb. to 49.48 ± 1.50 lb. and 43.53 ± 0.87 lb. to 46.21 ± 1.02 lb. respectively in the first three generations. In the second, third and fourth calvings the average weights of the male and female calves lie between 51.25 ± 1.23 lb. and 59.60 ± 3.47 lb. and 47.00 ± 2.12 lb. and 49.10 ± 1.54 lb. respectively.

(ii) The calves of the first calving weigh about 3 to 6% less than those of the succeeding ones ;

(iii) The difference between the weights of the calves of the different generations is not significant for any of the calvings.

(iv) The male calves weigh about 4 to 12% more than the famale calves.

Growth studies :—In general, the growth rate was maximum for the interval 25-49 weeks. The average rate of growth in the first twentyfive weeks for the starting heifers was 24.25±0.58 lb., for the progeny it varied from 20.45±0.56 lb. to 21.50±0.53 lb. The average rate of growth for the period 25-49 weeks was between 24-23±0.94 lb. and 28.11±0.74 lb. for the different generations. For the period 49-73 weeks the maximum and minimum averages were 20.63±0 51 lb. and 18.69±0.93 lb.

The weights for the various progeny are almost the same for the respective services and calvings. The age at first calving for the starting heifers is two months more than those of the subsequent progeny. But the weights at service or calving do not show any significant difference. This indicates that the weight is likely to be a better criterion of maturity than age.

The increase in the weight of the cows (actual or %) is maximum in the first gestation. There is considerable difference between the increase in the weight of individual cows.

The minimum weight is reached roughly 12 to 15 weeks after calving. The decrease in growth per week is minimum in the first lactation. There is considerable fluctuation in the growth of individual cows during the period calving to service.

The gain in weight for the period service to date of drying begins near about 20 to 33 weeks before drying, and goes on increasing steadily from week to week.

The weekly gain in weight during the dry periods is almost the same in all lactations and progeny.

From calving to service the cows lose in weight at an average rate of 0.95 lb. to 6.62 lb. per week. From service to date of drying they gain in weight at an average rate ranging from 1.58 lb to 3.88 lb. per week. During the dry period they steadily gain in weight at a rate ranging from 5.10 lb. to 8.20 lb. per week.

Correlation studies :—The correlation coefficients between average yield and wet period is positive and significant for the first four lactations for the pre-experimental period. They are significant for the first and second lactations only for the period 1932-42.

The correlations between average yield and service period are significant for the first and second lactations in the pre-experimental period and for the first and third lactations during 1932-42. This indicates that in the first, second and third lactations delay in service will result in higher wet average. In the subsequent lactations, the averages are not affected by the length of the service period.

The coefficients of correlation between average yield and previous dry period are not significant; which shows that the yield in any of the lactations is not affected by the previous dry periods.

The correlation between service period and age is, on the whole, not significant; which shows that the service period is not affected by age. Similarly the correlation between service period and wet period for the period 1932-42,

is not, in general, significant ; which appears to be due to the fact that it is the general policy to milk the cows for 305 days as far as possible.

The coefficients of correlation between the average yield per day and the weight at calving in different lactations for the period 1932-42 show that cows which weigh more are likely to yield more than those with less weight.

The correlation coefficients between average yield per day and increase in weight from service to calving are significant for the second and third lactations only. This shows that as the cows put on more weight from service to calving after the first and second services, they are likely to give more milk in the succeeding lactation.

The correlations between the average rate of decrease or increase in yield and the average rate of decrease in weight per week from calving to service are, in general, negative and significant for the first and third lactations only, which means that when the average rate of loss in weight is less, the average rate of drop in yield will be more and this can happen only when the fall in the yield starts very early.

Correlations between dams and daughters for the period 1932-42 have been worked out for a number of factors but none of them is significant, showing that the behaviour of the dams in growth, milk yield and persistency in lactation is not, in general, related to that of the daughters.

Effect of season on milk yield, service period and number of services :— The yield of cows calving in different months is governed considerably by the nature of fodder available at the time of calving. Considerable fluctuation in the yield is likely if the fodder is changed from day to day.

The average yield for all the lactations together for the period 1904-32 indicates that the yield of cows calving in July, August, September and November is slightly less than those calving in other months. The averages for the first four lactations for the period 1923-1932 show that, in general, the yield of cows calving in May, August to January is less than that for those calving in the remaining months. The yield of cows calving in September to December is least and is less than those calving in May and August. The results for the period 1932-42 are not the same as those for the former period. The figures for the different lactations show that cows calving in June, August and December are likely to yield less than those calving in the other months.

The average number of services required for conception is more or less the same for the first five lactations, but it is more for 6th to 9th lactation. It has been found that the fertility of service is not in any way affected by season.

The gestation period is not in any way influenced by either the month of calving or the age of cows.

Effect of temperature and humidity on milk yield :—In the majority of cases the effect of both temperature and humidity is not significant. However, the negative correlation between temperature and yield shows that when the temperature is low, the yield is likely to be high and *vice-versa*.

Effect of symptoms of Johne's disease on weight, yield etc. :—The differences between the birth weights of normal and Johne's disease cows are not significant.

There is no significant difference between normal cows and those suffering from Johne's disease as regards age at first calving.

The difference between the wet averages for the normal and Johne's disease cows are not significant in any of the lactations or progeny. In fact the latter ones have given slightly less milk. There is, however, no reason to believe that high yielders are more susceptible to Johne's disease than low yielders.

Comparing the average yield, the dry period, the weights at calving and at service, and the growth of daughters suffering from Johne's disease with their dams, no significant difference between normal cows and cows showing symptoms of Johne's disease has been observed.

REPORT OF THE DIVISION OF BOTANY

I. RESEARCH

A. Study and Improvement of Indian wheat (*Triticum* spp.).

1. *Survey of Indian wheat:*—The study of the all-India collection of samples of wheat was continued and observations on morphological and economic characters recorded. 200 varieties of wheat were again grown at Delhi, Pusa and Coimbatore with a view to testing their performance under different climatic conditions. Observations recorded at Delhi on two sets of six varieties each, one grown in the previous season at Coimbatore and the other at Delhi, appeared to indicate that climatic conditions prevailing in the previous season during the growth of the crop affect the performance of the crop in the succeeding season. At Simla the studies of hill wheats were continued.

2. *Description and registration of commercially important varieties and those of special interest for plant breeding:*—The varieties of wheat under study for registration were grown and described as in the previous years. Herbarium specimens of representative types were prepared.

3. *Study of wild and cultivated wheat species and allied plants:*—The F_6 generation of the intergeneric hybrids, *Triticum vulgare* × *Secale cereale* and *T. vulgare* × *Aegilops caudata* was studied and promising plants possessing economically-valuable characters like high tillering, long ears, amber and red-coloured, well-filled grains and resistance to rust were isolated and selected. The plants resembling *T. sphærococcum* obtained in the progeny of *T. vulgare* × *Ae. caudata* were studied and selections were made for further observations. Genetical studies in the F_4 and F_5 generations of *T. Vavilovi* × *T. vulgare* and *T. Vavilovi* × *T. Sphærococcum,* were continued and observations on the mode of inheritance of 'branched ear', 'extra glume' and glume colour characters were taken. The data so far obtained are being analysed. The collection of grasses allied to *Triticum* was under study and observations were made on their floral biology. A few of them like *Agropyron intermedium, A. elongatum, Elymus juncus* were studied with regard to their photo-requirements. The F_1 generation of the new interspecific crosses obtained in the previous year was grown and studied with special regard to fertility. Crosses of *T. Vavilovi* and *T. Spelta* (n = 21), *T. durum* (n = 14) and *T. Polonicum* (n = 14) were fairly fertile. The F_1 is of the intergeneric crosses, *Ae. triuncialis* (n = 14) × *T. vulgare* (n = 21) and *Ae. triuncialis* × *Secale cereale* (n = 7) were, however, completely sterile.

The progenies of the different interspecific crosses involving *T. Vavilovi, T. vulgare, T. durum* and *T. Timopheevi* were studied for important agronomic characters and further suitable selections were made.

4. *Experiments on smut resistance:*—The work of testing of varieties, including new strains of hybrid origin, for resistance to loose smut, was continued in co-operation with the Mycology Division and observations of the previous years confirmed.

5. *Breeding for rust resistance:*—At Delhi, 90 selections of rust resistant hybrids were artificially inoculated and tested for adult resistance ; further selections were made. A few promising cultures were harvested in bulk for small-scale multiplication in the coming season.

At Simla*, selections and trials for resistance to the three rusts, also combining desirable economic characters, were continued. This work is being carried out in collaboration with Dr. K. C. Metha.

* At the Potato and Wheat Breeding Substation, financed by the Indian Council of Agricultural Research.

6. *Miscellaneous:*—The collections of wheats from Baluchistan and Persia were maintained and studied. F_2 progenies of crosses between Baluchistan local wheats and some I. P. and other wheats were studied for maturity, rust resistance and habit; a number of promising plants were selected.

Tests and trials of newly-evolved strains of hybrid origin were in progress at Delhi and Pusa ; some of these appear to be promising.

B. Breeding for Disease Resistance and other Qualities.

POTATO (*Solanum tuberosum* L. and *Solanum* spp.)

1. *Performance tests with hybrid cultures:*—At Delhi 1,530 hybrids, including 783 hybrids received from Bhowali and Simla during the year under report, were planted under observation rows Notes on growth, vigour, disease incidence, yield and tuber characters were taken and further selections made. At Pusa, trials of hybrids have shown the superiority of certain hybrids over the local varieties.

2. *Yield trials of the promising hybrids:*—Three yield trials were conducted. In the first, 61 hybrids (including the 13 hybrids selected from the last year's preliminary trial) selected at Delhi during 1944-45 were tried against the local varieties in 6 replications, each of 1 line of 8 plants. A few hybrids did well or even better than the local varieties, which, being later in maturity, gave a lower yield than their average, probably due to more adverse effect of frost which occurred in the last week of December, 1945. In the other two trials, hybrids which were sent to the provinces for trials, were tried. The material received from Bhowali appeared to be partially dormant at the time of planting; its performance, therefore, was poor. The trials will be repeated.

3. *Experiments with 'tops' and sprouts:*—The 'tops' of *Phulwa* were planted along with halves and whole tubers. As in the previous year, the yield from the 'tops' was fairly good. Sprouts of *Phulwa* were sown in boxes and later transplanted in the field. However, the seedlings were badly damaged by the frost as they had not properly established when the frost occurred. The yields obtained from the sprouts, therefore, could not be compared with those obtained from the controls.

4. *Experiments on the artificial production of chimeras:*—Grafts involving potato, tomato, some species of tobacco and other solanaceous plants were made; chimeral shoots observed in certain cases were under study.

5. *Study of the Indian and European collection:*—The collection of the commercial varieties of *S. tuberosum* was maintained at Delhi as in the previous years.

At Simla, at the Potato and Wheat Breeding Station financed by the Indian Council of Agricultural Research, the studies of the Indian and European collections of varieties of *S. tuberosum* and other *Solanum* species and the breeding for resistance to late blight and other diseases were continued. The trials of new hybrids evolved at Simla were continued at a number of centres in the Provinces and States. A new method, in which sprouts and sprout-cuttings were utilised for propagating the potato plant, was developed.

At Bhowali, promising hybrids were multiplied for trial in the plains.

PIGEON PEA (*Cajanus Cajan* (L.) Millsp.)

The study on wilt resistance was continued ; resistance tests were in progress with 12 hybrid cultures of the cross between I. P. 24 and I. P. 51, two I. P.

types and two Burma types under artificially-infected field conditions, in collaboration with the Imperial Mycologist. The hybrid, C 38-3-1, appeared to be completely immune. I. P. types 80 and 41 showed only 1 per cent loss and the Burma types nearly 60 per cent loss due to wilt.

LINSEED (*Linum usitatissimum* L.)

The selections of strains resistant to linseed rust (*Melampsora lini*) were grown, along with I. P. types and other hybrid cultures, both at Delhi and Karnal. The incidence of rust was moderate at Delhi and heavy at Karnal during the year under report. Out of the 110 strains tried for resistance, only 2 showed slight infection at Karnal and one at Delhi ; all the I P. types and other cultures, on the other hand, were affected to varying degrees.

The progeny of the F_4 generation of the crosses involving I. P. types and Bolley Golden (a variety from the U. S. A., reported to be wilt and rust-resistant) was grown and suitable selections made.

The dual-purpose strains of linseed-flax hybrids bred for fibre and seed were grown at Pusa. The fibre, however, could not be extracted for want of a suitable machine for extraction.

TOBACCO (*Nicotiana* spp.)

Breeding strains of N. rustica with high nicotine content:—The F_7 progenies of the intervarietal crosses in *N. rustica* were grown and a number of single plant selections made on the basis of growth, vigour, leaf-size, leaf-colour, leaf-puckering and maturity. From the analysis made by the Imperial Agricultural Chemist for nicotine content, some of the selections appeared to be promising.

Breeding strains of Virginian tobacco suitable for North Indian conditions:—The F_7 progenies of the various cigarette tobacco crosses were grown and studied at Pusa and promising selections made for further breeding work.

Research on tobacco carried out at the Tobacco Research Substation, Guntur:—The studies on the effect of various manures and their combinations including the trace elements and the effect of rotation on the quality and yield of cigarette tobacco were continued. The varietal trial with Harrison's Special, Amarello 5, Hybrid 1 (F_1, Harrison's Special × Amerallo 5), Yellow Twist and Improved Yellow Mammoth was repeated ; Hybrid 1 and Amarello 5 gave the highest yield and the highest percentage of bright leaf.

Further selections showing considerable resistance to mosaic were made from the progeny of the cross, Harisson's Special × Ambalaema.

Experiments on the control of *Orobanche* were continued Neither the method of growing trap crops nor the treatment with Atlacide seemed to be effective. The effect of organic matter compost in eradicating *Orobanche* seed from the soil was under study.

C. Cytogenetical Studies in the Brassicae.

1. *Classification:*—The study of the collection of cultivated *Brassicae* was continued and the tentative system of classification into species and varieties, which has been evolved, was confirmed. A number of varieties brought from China were again grown and studied with regard to their fertility.

2. *Inbreeding:*—Inbred progenies were obtained in a number of diploid types of *toria* and *sarson* by continued selfing over a number of years. These were studied morphologically. It is proposed to utilise these inbreds in the future for producing vigorous hybrid combinations.

3. *Genetical Studies :* (a) *'Dyad mutant' in toria:*—In one of the selfed progenies of *toria,* a mutant plant which produced dyads, instead of forming the normal tetrads, was found. This is the second such mutant recorded in the plant kingdom, the first one being recorded in *Datura.* With a view to studying the inheritance of this character, reciprocal crosses between the 'dyad' plant and diploid and tetraploid plants of *toria* were made.

(b) *'Clumped pollen' mutant in toria:*—A mutant plant in one of the inbred *toria* cultures was found to have tetrahedrally-clumped pollen grains even at as late a stage as anthesis. Suitable crosses were made to study the inheritance of this mutant character.

(c) *The 'male sterile' character in toria:*—A number of male sterile plants was isolated. They were found to be totally pollen sterile despite regular pollen meiosis. Preliminary observations showed that male sterility is a recessive character in these plants. Crosses were made for further investigations.

(d) *Inheritance of olive-green leaf colour in toria and sarson:*—In *toria,* preliminary observations have shown that the olive-green character of the leaf is dominant over the normal. Further crosses involving these parents were made for a detailed study. In yellow *sarson,* however, abnormal segregation in respect of the olive-green and the normal colour of plants was observed in the different progenies of crosses involving these characters. Reciprocal crosses between the normal and the olive green plants were, therefore, made using pure as well as mixed pollen of the two types for studying its inheritance with special reference to competitive pollen-tube growth.

(e) *Inheritance of self-sterility in taramira* (*Eruca sativa*)*:*—The study was taken up during the year under report ; selfing, bud pollination and group-crossing were made. The data are being analysed.

4. *Artificial induction and study of polyploids:*—(i) *Breeding behaviour of the tetraploids:*—Large population of the colchicine-induced tetraploids of the several species of *Brassica, viz., B. nigra, B. campestris* var. *toria, B. campestris* var. *sarson* (yellow *sarson*) and the apetalous mutant, *B. Tournefortii* (wild *Brassica*) and *Eruca sativa* (*taramira*) were grown and studied with regard to growth, vigour, morphological characters, cytological behaviour, fertility and crossability as compared with the corresponding diploids. Promising plants were selected. A large population of tetraploid *toria,* comprising nearly 6000 plants was studied with regard to growth, maturity and fertility. Promising plants, some of them as fertile as the diploids, were selected. The study of the crossability of tetraploid yellow *sarson* with tetraploid *toria* and diploid *rai* was in progress ; it was found that about 5.7 per cent of the plants in the population of tetraploid *sarson* were natural crosses with the former and about 4.8 per cent with the latter. Experiments on bud pollination indicated that improved seed setting was obtained by this method in *toria* while in *sarson* the setting was decreased by making bud pollinations.

(ii) *Study of the causes of sterility in autotetraploids* of *B. campestris with reference to cytological features:*—A number of cultures of tetraploid *toria* obtained from open pollinated, selfed and crossed (intervarietal and intravarietal) seeds were being studied from the points of view of fertility, compatibility and cytology. Crosses were made to diversify the self-sterility genes in tetraploid population of *toria* with a view to studying the effect of such a diversification on fertility. Autotetraploids were also obtained from open pollinated and selfed seeds of different diploid types of yellow *sarson* and *toria* for this study, which will be continued next year.

(iii) *Comparative study of growth and development in diploid and autotetraploid toria* (*Brassica campestris*, L. var. *toria*):—Seeds of the diploid and the autotetraploid forms were sown in replicated rows and periodical measurements of growth were done ; the observations comprised germination, growth in the seedling and the adult stages, tillering, flowering, fertility, pod formation and the size and yield of plants. The data are being analysed.

D. Fundamental Cytological Research.

1. (i) *Colchicine-induced polyploids of crop plants*:—The C_8 generations of tetraploid gram (*Cicer arietinum*) and chilli (*Capsicum annuum*) and the C_4 generation of tetraploid *Sesamum orientale* were grown and studied with regard to growth, fertility and other economic characters ; the high degree of seed-sterility in the case of *Sesamum*, despite low pollen-sterility, appeared significant. Autotetraploids of gram and chilli also did not indicate any improvement in fertility. Autotetraploids were obtained by colchicine treatment of a number of varieties of chilli and *Sesamum* with a view to studying in the following years the effect of intervarietal hybridisation between autotetraploid forms on fertility. Crosses between diploid and tetraploid forms, attempted during the previous years and in the year under report, gave rise only to matromorphic plants indicating their origin presumably through apomixis. Interesting results confirming this hypothesis were obtained when progenies obtained from the pollination of an intervarietal *Sesamum* hybrid with pollen from the autotetraploid form were studied during the year under report ; these crosses were repeated to seek further confirmation of these results

The A_4 progenies of the amphidiploid *Sesamum indicatum* (2n=58), obtained from colchicine treatment of the sterile F_1 hybrid *S. orientale* (2n=26) × *S. prostratum* (2n=32), were grown and studied with regard to morphology, cytology and fertility. They bred practically true to type and chromosome number as in the previous years ; a number of sterile hybrid plants of parthenogenetic origin were again discovered in these progenies besides a few natural crosses to *S. orientale*.

(ii) *Collection and study of wild relatives of crop plants*:—The collection of wild and allied species and genera of crop plants was maintained for study ; a number of additions to the collection were made. Suitable forms among these were used for hybridization. The following are of particular interest :—

(a) *S. orientale* (2n=26) × *S. prostratum* (2n=32) : Primary back-cross progenies of the amphidiploid, *S. indicatum* (2n=58), were grown and studied with regard to morphology, cytology and fertility. In the progeny of the backcross of the amphidiploid to tetraploid *S. orientale*, a plant of parthenogenetic origin, having the appearance and chromosome number of the F_1 hybrid between diploid *S. orientale* and *S. prostratum* was found to be pollen fertile, unlike other plants of such origin which, like the original F_1 hybrid, were totally sterile. This was observed to produce dyads subsequent to the formation of restitution nuclei during pollen meiosis. Suitable crosses were attempted to study the inheritance of the dyad-forming character.

Progenies obtained from selfing, open-pollination and secondary backcross to *S. orientale* of the triploid hybrid, *S. indicatum* × *S. orientale*, were under study with regard to morphological, cytological and economic characters. Interesting results were obtained indicating the transference of either whole chromosomes or genes from the wild *S. prostratum* to the cultivated *S. orientale*. These studies will be further continued.

Crosses were also attempted between *S. orientale* (2n=26) and an exotic species *S. radiatum* (2n=64).

(*b*) *Solanum Melongena* × *S. incanum:*—The F_5 progenies of this cross were grown and studied for spininess, colour, size and bitterness of the fruit and resistance to borer-attack. Promising plants were selected for further study.

(*c*) *Lycopersicon esculentum* × *L. pimpinellifolium:*—Further selections were made in the filial and back-crosses progenies of this cross combining good yield, larger fruit size and early maturity. Determinations of vitamin C content in these selections, the parental types and hybrids were made with the co-operation of the Imperial Agricultural Chemist. The small-fruited selections had the highest vitamin C content; some of the figures (mgm. ascorbic acid per 100 gm. of fresh material) were as follows:—*L. esculentum* (var. Earliana), 29.2; *L. pimpinellifolium*, 36.7; F_1 hybrid, 35.9. The values for the nine selections tested ranged between 19.5 and 46.3.

2. *Other genetical investigations*:

(*i*) *Inheritance studies of mutations*:

(*a*) *Leaf mutations in gram* (*Cicer arietinum*):—The results obtained in these studies, involving crosses between the different mutants including the 'Narrow-leaf' were analysed and written up for publication.

(*b*) *The 'Cawnpore Mutant' in Pigeon pea* (*Cajanus Cajan*):—The F_2 and F_3 progenies of the cross involving the mutant and the normal characters were studied and the existence of duplicate genes governing the mutant characters was confirmed.

(*ii*) *Study of the inheritance of sex in Luffa:*—Study of the crosses between the different sex types in *L. acutangula*, reported in the previous years, was continued. The results indicate that the monoecious condition is governed by two dominant genes. The presence of either of these in the recessive condition produces femaleness (gynoecious) or hermaphrodite+maleness (andromonoecious); the double-recessive produce the hermaphrodite condition.

E. Physiological Investigations.

1. *Drought-resistance studies with wheat:*—(i) A comparative trial of 260 exotic and Indian wheats grown under 'dry' and irrigated conditions, as well as a field trial of 35 selected varieties have again confirmed the correlations between the time of flowering and growth and yield and the temperatures prevailing during the ripening period. This was further corroborated by a study of grain development in varieties selected from different flowering classes.

(ii) Determination of resistance to wilting has again shown that during the early stage there are hardly any measurable differences in all the varieties and species studied so far. Considerable reduction in grain yield and 1000-corn weight was observed in the late varieties as a consequence of wilting during the shooting stage.

(iii) In an experiment to determine the resistance to wilting after synchronization of the growth and developmental phases of different varieties, it was observed that the temperature of the desiccation period had also a considerable effect on the recovery of plants.

(iv) A large-scale field trial of pre-treated seed of I. P. 4 wheat gave a grain yield of 1556 lb. per acre as against 1245 lb. per acre from untreated seed under unirrigated conditions.

2. *Photoperiodism and vernalization*:—A complex experiment involving seven light treatments and nine varieties of six different species of wheat was carried out in pots. Growth observations and harvest data indicate that (*a*) acceleration in the developmental process of wheat is progressively greater, the greater the amount of light received by the plants in a given time; (*b*) stem growth, tiller production and other growth characters are correlated with the rate of developmental process; (*c*) light and heat requirements of different varieties are different and the temperatnre and the light effects are interrelated; (*d*) vernalisation and photoperiodic experiments have helped in confirming the findings in the drought-resistance experiments. These data have also proved useful in understanding the nature of the inheritance of growth and development.

With the co-operation of Mr. Boshi Sen of Almora, forty wheat varieties, which had responded to vernalisation in the previous years, were vernalised and sown in replicated plots along with untreated controls. Earing was observed to be earlier in all but three of the vernalised cultures as compared to the controls.

Seven varieties out of those which had exhibited differential response with regard to flowering and maturity when grown at Delhi and Coimbatore were subjected to vernalisation during the year under report and grown at Delhi and Coimbatore. The results indicate that plants from the Delhi-grown unvernalised seeds flowered from 2 to 9 days earlier than those from the unvernalised Coimbatore-grown seeds; there was, however, little difference in the time of flowering in the case of vernalised seeds.

Experiments were started in which *Triticum Vavilovi* was subjected to vernalisation treatment to induce earliness in flowering in that variety. The experiment is proposed to be repeated in successive years with a view to determining whether this variety of wheat, which almost invariably fails to flower in the plains of India, could be 'trained' to do so by vernalisation in successive years.

3 *Studies on salt resistance in wheat*:—Germination studies with pretreated seed under restricted water supply as well as in the presence of salt in the medium have again shown that pretreatment with water as well as with NaCl solution accelerated germination and early growth.

4. *Genetics of physiological characters*.—Pleiotropic nature of genetic factors for the developmental process as well as the production of phenocopies has again been demonstrated.

5. *Studies of plant hormones and chemical regulation of growth and development in plants*.—A preliminary study on the effect of synthetic growth substances on the growth of plants was taken up.

F. Miscellaneous Studies.

1. *Study of hybrid vigour and the possibility of its exploitation in agriculture*:—

(*a*) *Brinjal and Bitter Gourd*.—Observations on the manifestation of hybrid vigour in the different filial generations were continued; the data collected are being computed.

(*b*) *Maize.*—Experiments on inbreeding and on hybrid vigour were continued. Seeds of a number of commercial varieties, inbreds and single and double crosses were obtained from a number of foreign countries; this material will be utilised for study under a scheme for the improvement of maize in India financed by the Indian Council of Agricultural Research.

2. *Seed-setting in berseem*:—(i) Five varieties were grown for seed-setting studies at Delhi and Pusa. Observations on flowering, bee-visits and seed-setting were recorded on plants both cut and uncut; the results indicate that the yield of seed tended to decrease as the number of cuts taken increased. Single plant selections for improved seed setting in each variety were made.

(ii) *Vernalisation*:—With a view to inducing early flowering which would synchronise with the period of maximum bee-visits necessary for adequate pollination, five varieties of berseem were subjected to vernalisation, the seeds being soaked for varying periods in water and in solutions of different strengths of potassium chloride before the treatment. Observations recorded during February and March showed that the treated plants flowered at the same time as the controls. It is proposed to repeat the treatments with suitable modifications.

(iii) *Colchicine treatment*:—Dry and germinated seeds were subjected to colchicine treatment with a view to obtaining polyploids which would give greater fodder yield and an increased vegetative period. No polyploids were, however, isolated from the treatments; it is proposed to repeat the experiments with suitable modifications.

3. *Performance tests of vegetables*:—The work taken up is to serve as a nucleus of the Central Seed Testing Station to be instituted later by the Government of India. Tests on purity, germination, performance and the cooking quality of a number of winter vegetables were conducted; the seeds were received from different places in India and the U. S. A.

4. *Crop outturns and seed distribution*:—The total rainfall during the year under review was 26.48 inches. The distribution was not even, about 10.60" rainfall having been recorded in September alone. In winter, there was very little precipitation.

The continuous and heavy rains in September very much delayed the preparation of land and the *rabi* sowings.

Frost occurred on a few days in December and January. It was rather severe on the 30th and 31st December. Pigeon pea and most of the Solanaceous crops were damaged, the damage in the latter case being rather severe.

The yields of most of the crops, except gram, were much below normal which may be due to delayed sowings and unsatisfactory and hurried preparation of land. The gram yields were much above the average. Wilt or insect attack was practically absent.

Statement of yield of crops in the Botanical Division During 1945-46.

Crop	Plot	Area in acre	Outturn of grain in lb.		Remarks
			Actual	per acre	
Wheat					
I. P. 4	10	1·00	1168·5	1168·5	Did not receive any irrigation.
I. P. 121	22	0·5	1265·2	2530·4	
I. P. 125	48	2·25	576·0	2304·0	
Barley					
I. P. 13	32	1·30	1117·0	859·9	Plot was not manured.
Oats					
I. P. 1	43	0·5	1232·2	2464·4	
I. P. 2	43	0·5	1217·8	2435·6	
I. P. Hyb. 1	52	0·5	432·0	864·0	
I. P Hyb. 3	49	0·65	876·4	1347 4	
X-27	52	0·5	687·1	1374·2	
Gram					
I. P. 17	54	0·5	1049·1	2098·2	
I P. 25	54	0·5	929·8	1859·8	
I. P. 53	50	1·0	2034·5	2034·5	
I. P. 58	51	1·0	1841·2	1841·2	
Peas					
I. P. 29	27	0·94	1464·7	1557·3	

II. ADVISORY

As in previous years, a large number of enquiries was received from all over the country and from abroad regarding varieties of crops, exchange of seeds and other material, methods of breeding and cultivation, economic wild plants, tobacco curing, etc., and the information asked for was supplied.

A number of plant specimens were identified for various correspondents. A number of scientific articles were also referred for the Indian Council of Agricultural Research.

III. PROGRAMME OF WORK (1946-47)

1. Studies in the improvement of Indian wheats (*Triticum* spp.) will be continued.
2. The work reported on breeding crop plants for disease resistance and other qualities will be continued.
3. Cytogenetical studies in the *Brassicae* will be continued.

4. Work on the items reported under Fundamental Cytogenetical Research will be continued.
5. Studies on drought-resistance and salt resistance in wheat will be continued.
6. Experiments on vernalization and photoperiodism will be repeated with a view to confirming the findings reported.
7. Experiments on the inheritance of physiological characters will be continued.
8. Investigations on plant hormones and chemical regulation of growth and development in plants will be developed.
9. Studies in hybrid vigour, with special reference to maize and on the problem of seed-setting in berseem will be continued.
10. The miscellaneous crop collection will be maintained and further studied.
11. Work on performance tests of vegetables will be continued, subject to the scheme being extended by the Government of India.
12. The genetical investigations reported will be continued.

REPORT OF THE SUGARCANE EXPERT, COIMBATORE

I. INTRODUCTION.

This report embodies the work conducted at the Coimbatore Sugarcane Breeding Station as also at two of the Schemes connected with the Station, *viz.*, (i) Sugarcane Sub-Station, Karnal, and (ii) Scheme for Research on Sugarcane Physiology, Coimbatore. These two Schemes are financed by the Indian Central Sugarcane Committee. The work on cyto-genetics is being conducted by the Second Cane Breeding Officer.

II. SUGARCANE BREEDING.

(a) Hybridisation and Selection.

(i) Hybridisation :—In all about 200 crosses were effected excluding those for genetical studies. The more important of these are detailed below :—

The *bulk scale economic crosses* during the year were (1) Co.349 × Co.285, (2) Co.349 × Co.453, (3) Co.464 × Co.285, (4) Co.464 × Co.301, (5) Co.464 × Co.453, and (6) P.2607 × Co.440. Of these the Co.464 crosses are a repetition of last year's, as the flowering of Co.464 was meagre in that year and could not be effected on a satisfactory scale. But the Plant Physiologist was able to make this variety flower fairly profusely this year and it was consequently utilised on a satisfactory scale. The bulk scale cross Co 349 × Co.244 which was programmed to be done this year could be attempted only on a small scale owing to the disparity in the time of flowering of these two varieties. It is proposed to manipulate the flowering time of these varieties in the next seasons. The *semi-bulk scale crosses* were (1)Co. 270 × Co.301, (2) Co.464 × Co.545, (3) P. O.J.2878 × Co.453, and (4) P.O.J 2878 × Co.545. The germination of seeds in all the above crosses was satisfactory except in Co.270 × Co 301 in which it was very poor. A number of experimental crosses which had been planned were successfully effected.

In the *Sorghum crosses* the three sweet Sorghums of Uganda received from the Director, East African Agricultural Research Institute, Amani, Tanganyika Territory, were utilised for the first time, as male parents separately on P.O.J.213, P.O.J.2725 and Co.421. Co 630 which has Sorghum blood was crossed with Co.617 and also with G.2291, (Co.349 × Bamboo) a bamboo seedling. A broader leaved and vigorous variety of *Sorghum halepense* collected by the Station from Humpi was utilised in crossing mainly with a view to evolving fodder types. (*Vide* section on fodder crosses below).

In the *Bamboo crosses*, G.2291 was back crossed with Co.349. G.4938 (Co.421 × G.2291) was crossed with Co 244, Co. 453 and Co.605. The other two crosses in which Bamboo derivatives were utilised were Co 349 × G.4924 (Co.421 × G.2291) and G.4924 × Co.630.

In the *fodder crosses*, *i. e.*, crosses designed to yield fodder types, all the three fodder canes namely Co.559, Co.560 and Co.561 were crossed with Guinea grass (*Panicum Maximum*), *Sclerostachya fusca*, and Humpi variety of *Sorghum halepense*.

In the crosses designed to give *Early Ripening canes*, a new parent, *viz.*, Co.630 was utilised this year in addition to Co.349 and Co.508 which are repetitions of last year.

In the crosses for yielding *Late Ripening Canes*, Co.545 has now been utilised in three crosses as the experimental crosses made last year indicated that this parent yielded late ripening canes in all the combinations in which it was used.

In the crosses for studying *Pithy and Non-Pithy seedlings* the following three new combinations were effected :—(1) P.O.J.2725 × Co.301, (2) Co.421 × Co.301, and (3) Co.281 × Co.301. Similarly five new combinations for such studies have been effected using Co 244 as one of the parents.

(ii) Selection :—In the full grown population from the various crosses (*i. e.*, those effected last year) by far the best were those of the cross Co.349 × Co.301. The vigour, tillering and sucrose content of these seedlings were very satisfactory. Out of a population of 1,000 seedlings as many as 67 seedlings were selected for the Row-Trials. The next best combination was P.O.J.2878 × Co.301. The above two were the bulk scale crosses. Among the semi-bulk crosses, Co.508 × Co.301 is the only one which deserves mention. Even in this the seedlings are somewhat lacking in vigour. Out of the experimental crosses, Co.421 × Co.617 seems to be a desirable combination. The seedlings from this cross are very vigorous. Next to it are Co.370 × Co.313 and Co.508 × Co.453, which are fairly vigorous. In all 515 seedlings were selected for the Row-Trials. From the Six Row-Trial plots, eleven seedlings were raised to the status of Co. canes. Their parentages and general characteristics will be found elsewhere in this report.

(b) Study of Special Characteristics.

(i) *Early Ripening canes*:—The bulk scale cross Co.503 × Uba Marot yielded early ripening types with satisfactory vigour The experimental cross Co.527 × Co.508 also gave early ripening canes with fair vigour.

(ii) *Late Ripening canes*:—The experimental crosses (1) Co 270 × Co.545, (2) Co.385 × Co.545, (3) P.O.J.2878 × Co.312 and (4) Vellai × Uba marot yielded late maturing types.

(iii) *Pithy and Non-Pithy canes*:—Three new crosses with Co. 301 as one of the parents were studied and it was again confirmed that it contributes towards non-pithiness of seedlings. These combinations were (1) Co.349 × Co.301, (2) Co.421 × Co.301, and (3) P.O.J.2725 × Co.301, and the percentages of non-pithy seedlings were 69,57 and 52 respectively.

Similarly Co.508 also contributes towards non-pithiness of seedlings. Six combinations were studied with this variety as one of the parents and the above conclusion arrived at. It looks as though Co.508 is even better than Co.301 in this respect.

(iv) *Fodder canes* :—Eighteen varieties were grown against the three fodder canes Co.559, Co.560 and Co.561 as also Guinea grass, the last four being used as standards. Four cuttings were taken during the year and G.3472 and G.4545 were found to give better weighments as compared to the stand ards This is only a preliminary investigation and the characteristics which go to make a good fodder cane have yet to be determined including the relative fodder values.

(v) *Chewing canes* :—Of the half a dozen seedling canes mentioned last year one was raised to the status of a Co. cane (*viz* , Co. 634) more because of its performance as a general purpose cane rather than as a chewing cane. It is, however, fairly soft-rinded and may be pressed into service as a chewing cane. It is practically non-flowering and without pith. It is recommended that it may be tried as a chewing cane.

The evolving of a chewing cane is somewhat of a problem. It is easy to evolve a sweet and soft rinded cane by mating suitable 'noble varieties' but such seedlings often lack vigour. The successful chewing canes are E.K.28 and B.6308. The former was originally a general purpose cane but has now been pressed into service as a chewing cane. It is by no means soft-rinded at least to the extent that a chewing cane should be. B.6308 is, on the other hand, quite all right.

III. INVESTIGATIONS.

(a) Taxonomic studies.

(i) Taxonomic position of *Erianthus* :—Morphological studies were undertaken of all the available varieties at the Station belonging to the different species of the genera *Saccharum, Erianthus, Sclerostachya* and *Narenga*. The position as regards *Erianthus* is that according to some, all the species of *Erianthus* should be transferred to *Saccharum* while others would reduce certain species of *Saccharum* and place them under *Erianthus*. Particular attention was therefore paid to the forms of *Erianthus* at the Station as also the forms now being labelled as *Saccharum munja* and *Saccharum arundinaceum*.

The studies at the Station lead to the conclusion that *Erianthus* should be separated from *Saccharum*. It should form a separate genus as it shows the following distinct characters in contradistinction to *Saccharum* : (1) culms biennial, (2) root eyes mostly absent ; if present only one row, (3) leaf insertion finely bearded extending into the mid-rib, (4) callus hairs shorter or as long as the spikelets, never longer, (5) glume I and II of pedicelled spikelet always villous dorsally and often glume I of sessile spikelet, (6) glume IV always present, prominently awned in most cases, often being exerted beyond the spikelet and (7) glume IV ovate lanceolate.

The above distinct characters were also found in the forms now being labelled as *Saccharum munja* and *Saccharum arundinaceum* which should therefore be transferred to *Erianthus*. One important point of difference between the two genera which is rather significant is the villous nature of the first and second glumes of the pedicelled spikelets in all the species of *Erianthus*. This gives the flowers a woolly appearance and the very word *Erianthus* itself means 'woolly flowered'.

A study of the forms of *Erianthus* including those of *Saccharum munja* and *Saccharum arundinaceum* further shows that in the genus *Erianthus*, three groups can be distinguishable each with a type species, *viz.* (1) *E. Ravennae*, (2) *E. Munja* and (3) *E. arundinaceum*. There are many characters distinguishing these groups.

(ii) Probable origin of *Saccharum officinarum* :—The above studies give an indication as to the probable origin of the noble canes belonging to *S. officinarum*. Some of the characters of *Erianthus* are noticed in *S. officinarum* to the exclusion of the other species of *Saccharum*. These are (1) the earlier opening of the sessile spikelets, (2) the glabrous nature of the peduncle, (3) the occasional presence of an awn to the IVth glume, (4) glumes I and II with three or more nerves and (5) glume III with one median nerve. These characters are common between *Erianthus* (all the three sub-groups) and *S. officinarum*. One sub-group, *viz.*, *E. arundinaceum* has more points of resemblance to *S. officinarum*. The forms are vegetatively very similar to those of *S. officinarum* in size, thickness of stem and nature of leaves. They are propagated by setts and the arrows are showy and large as in the varieties of *S. officinarum*. The similarity in characters leads to the inference that species of

Erianthus, especially *E. arundinaceum* might be considered as probable source of the origin of cultivated canes. Brandes and his Co-workers were also led to the same conclusion basing their observation on the venation of the spikelet parts, *viz.*, points (4) and (5) above.

(b) Frost Resistance Studies.

Of the protoplasmic qualities mentioned in the previous report, attention was confined during the year only to sap concentration. Though no difference was noticed in sap concentration under normal temperature in the different varieties tested, it was found, however, the varieties showed marked changes in osmotic concentration under low temperature. This change in osmotic concentration was employed in distinguishing resistant and susceptible cane varieties.

Plasmolytic method was employed for the determination of osmotic concentration of the tissues, using Calcium chloride as the plasmolysing agent and Neutral Red as the stain for determining the incipient Plasmolysis. Sections of stalk, leaf sheath and mid-rib were used. For conducting the experiment batches of 5 to 6 weeks old seedlings raised from setts of different cane varieties were subjected to low temperature of 3 to 5° C. At intervals of 12, 24, 48, 72, 96, 108 and 120 hours a plant was removed and osmotic change in the tissues determined.

Twenty varieties were studied and the range of osmotic concentration variation under low temperature was from 0.03 M to 0.15 M. Those showing the range from 0.12 M to 0.15 M may be considered frost resistant ; those falling within a range of 0.07 M to 0.11 M as moderately resistant and those with a range from 0.03 M to 0.06 M as not resistant. The varieties Co.281, Co.290, Co.453, and Co.605 come under the first category. The varieties Co.205, Co.285, Co.637 and Katha fall under the second category, while the varieties Co.313, Co.421, Co.617, Co.634, Co.635, Co.636, Co.638, S.s. Tank, S.s. Glagah, and M.11292 under the non-resistant class.

(c) Studies on Sugarcane seed.

(i) Germination of stored seed :—The seed of Co.419 and P.O.J.2878 stored under three different conditions of storage during last year was tested for viability during January, February and April of this year (1948). The fresh seed of the varieties collected during this season was used as control. The number of seeds germinated per one gram fluff of seed stored under different conditions as compared to control is given below.

Condition of storage	Co.419			P.O.J.2878		
	Jan.	Feb.	Apr.	Jan.	Feb.	Apr.
1. Preserved in tin with Co_2	105	97	92	90	82	82
2. Preserved in tin without Co_2	92	83	81	73	68	69
3. Preserved in paper packet	nil	nil	nil	nil	nil	nil
4. Fresh seed in paper packet	257	100	57	189	118	74

(ii) Enzymes of fresh seed of Co.419 :—A determination of the enzymes of fresh seed of Co.419 showed the presence of large quantities of Diastase and Invertase. The determination of other enzymes could not be done because of non-availability of the required chemicals.

(iii) Chemical composition of fresh seed of Co.419 :—The fresh seeds of Co.419 were analysed and the data are given below. All percentages are expressed on oven dry seed sample.

Constituents	Percent	Constituents	Percent
Fat	6·958	P_2O_5	1·923
Crude Fibre	2·637	K_2O	0·761
Sugars	less than 0·050	CaO	0·294
Starch (Acid hydrolisable)	45·220	MgO	0·498
Pentosans	0·318	Fe_2O_3	0·451
Total Nitrogen	4·395	Al_2O_3	0·201
Ash	7·114	Mn	0·020
Sand and Silica	3·449	Zn	Trace

The Chemical analysis of the stored seed is in progress.

(*d*) Chemical Studies.

A preliminary study has been made of the more important Co. canes with regard to the chemical constituents which affect manufacturing quality of sugar. Determinations were made on the following constituents :—sucrose, fibre, acidity, total nitrogen, gums, colloids, total ash, P_2O_5, CaO and MgO, sulphates and K_2O and the varieties taken up for study were:—Co. 213, Co. 285, Co. 290, Co. 312, Co.313, Co.331, Co.356, Co.419, Co.421, Co.453, Co.513, and Co.527.

In sucrose content Co.527 with 18·08 per cent was the best followed by Co.421 with 16.84 per cent while Co.285 was the poorest with only 12.14 per cent. The fibre content varied from 10.51 per cent in Co.419 to as much as 22.71 per cent in Co.513. The varieties Co.285 and Co.313 also contained a high amount of fibre. Co.419 recorded the lowest titrable acidity while Co.285 4 and Co.290 had the highest acidity. The variation in Total Nitrogen was not much. The non-proteid nitrogen was high in Co.453 and Co.513 and least in Co.3 and Co.527. The amount of gums varied from 0.091 per cent in Co.419 to 0.15 12 per cent in Co.513. The range of variation in colloids was 0.309 per cent in Co.331 to 0.601 per cent in Co.285. There was considerable variation in total ash content extending from 0.361 per cent in Co.419 to 0.914 per cent in Co 285. There was also much variation in P_2O_5 content, i, e., 0.0747 per cent in Co.285 to 0.0191 per cent in C.527. As regards Calcium and Magnesium content there was very little variation and the amount of Calcium was very low and that of Magnesium a little higher. The figure for Sulphate is rather high, being as much as 0.1525 per cent in Co.356. The lowest was in Co.419, viz., 0.062 per cent. The variation in the potash content was more or less in agreement with the variation in Total ash content. Potash constituted more than 40 per cent of the total mineral contents in all the varieties. The individual amounts varied from 0.4044 per cent in Co.513 to 0.1497 per cent in Co.331.

* (*e*) Cyto-genetic Studies.

The results are similar to those of last year in respect of germination and viability of seedlings obtained in the crosses between different types of *Saccharum officinarum*. Only in one cross, viz., Red Mauritius × Kaludai Boodan, about 60 seedlings survived for planting and this indicates the possibility of reducing or eliminating to some extent the unfavourable genes for viability by repeated hybridisation among the seedlings of the progeny.

In the interspecific crosses, it is found that in general *S. officinarum* gives better germinations when crossed with *S. Barberi* than with *S. spontaneum* combinations. The study of the progenies of the crosses of *S. spontaneum* (Tank) with three different types of *S. officinarum* indicate the following : (a) the proportion of plants with 'ligular processes' present to plants where this character is absent, vary; (b) plants with higher brix content are found more in Kaludai Boodan and Lakhapur crosses than in Chittan × *S. spontaneum* and (c) a few exceptionally tall plants are found only in Chittan × *S. spontaneum*.

The character of production of egg gametes with a different chromosome number from the normally expected is not limited to the complex *S. officinarum* × *S. spontaneum* hybrid, Co.421, as reported in the previous year, but has also been found in the direct hybrids, as *S. officinarum* (D-74) × *S. spontaneum*, and *S. officinarum* (Vellai) × *Sclerostachya fusca*. In the light of this capacity of *S. officinarum* to give rise to exceptional egg gametes, the finding of chromosome number in Kajla (*S. officinarum*), 2n = 68, as against the characteristic number of 2n = 80 for *S. officinarum* is explainable on the basis of the origin of this cane as a result of this peculiar parthenogenesis in sugarcane.

From the cyto-genetical studies in sugarcane, an hypothesis on the probable origin of North Indian canes has been suggested. It is considered that the North Indian canes have evolved out of extensive hybridisation between *S. officinarum* and *S. spontaneum*. Though the *S. officinarum* types are believed to have been imported recently, this hypothesis shows that *S. officinarum* must have been in cultivation in peninsular India earlier than the origin of North Indian or indigenous canes. The following are evidences in support of the hypothesis : (1) The wide distribution of *S. spontaneum* in temperate and tropical regions and its ability to flower wherever found ; (2) the high polyploid nature of *S. officinarum*, and its ability to produce reduced and unreduced gametes, as also the occurrence of self sterility and intervarietal incompatibility are favourable contrivances for wide crossability ; (3) the capacity of sugarcane varieties to contribute to the progeny chromosome numbers other than the expected and the ability of unreduced and exceptional gametes to develop parthenogenetically; (4) experimental production of seedlings resembling more or less the North Indian canes and (5) the presence of ligular processes in *S. officinarum* and *S. Barberi* and its complete absence in *S. spontaneum*.

** (*f*) Plant Physiological Studies.

In the photoperiodic treatments, the top portions of the non-flowering variety, S. s. Soraparai 270, were subjected to the following treatments :— (1) Normal day light ; (2) Two hours day from 12 noon to 2 P. M. for a period of 15 days; (3) Two hours day for a period of 30 days; (4) Two hours day for a period of 45 days and (5) Two hours day for a period of 60 days. This variety flowered on 30 November, 1945, with the first treatment ; on the 10th December with the

* The work on cyto-genetics is conducted by the Second Cane Breeding Officer, Dr. N. Parthasarathy.

** The Plant Physiological studies are conducted by the Plant Physiologist, Mr. N. D Yusuf, in the Scheme financed by the Indian Central Sugarcane Committee.

second treatment ; on 2nd January, 1946, with the third ; on 9th January with the fourth and on 11th February with the last, showing a delay of about 73 days in its time of flowering as compared to the tops kept throughout under normal day light conditions. The intensity of flowering declined from 100 per cent with the first treatment to 20 per cent with the last mentioned treatment.

In the Irrigation and Manurial treatments, (a) Red Mauritius and Co.468, the two important thick cane varieties, which do not flower at Coimbatore, flowered profusely when subjected to the treatement of "alternate day irrigation". About 70 per cent and 72 per cent of the stalks flowered respectively. The canes in the 'Control' plot did not flower; (b) Poovan, another non-flowering thick cane variety and S. s. Assam (301), a non-flowering wild form, flowered with the treatment of daily irrigation. The plots were manured with a light dose of the mixture (bone meal and groundnut cake) applied at planting ; and (c) the variety p. 4626, which is late and sparsely flowering, flowered early and profusely with the daily irrigation treatment ; about 50 per cent of the stalks flowered. In the control plots this variety flowered a month later and produced only one arrow.

* IV. SUGARCANE SUB-STATION, KARNAL.

The Live-Herbarium at the Sub-Station now contains 715 varieties consisting of 319 Co. canes, 124 North Indian indigenous canes, 90 Exotic varieties, 80 Wild *Saccharums* and allied genera, 18 Co. Ks, and 84 other varieties. The Herbarium has been maintained efficiently by the Superintendent. There were no major diseases during the year and the borer infestation was light.

As regards the flowering habits, it is noticed that the percentage of flowering in the Burma form of *S. spontaneum* is declining. In 1942 fifty arrows were obtained in a row of 20 feet length whereas in the 1945 flowering season only four shoots were in flower. The Russian form of *S. spontaneum* flowered for the first time (in April) after it has been in the collection for three years. Probably due to late rains in September many of the Co. canes which have not flowered so far at Karnal came into flower in February and March.

Line drawings and morphological descriptions of all the important varieties have been recorded. In addition to the usual characteristics the angle which the shoot makes at the time of germination, the curvature of leaves and the sheath colour of all the varieties have been recorded as an aid in the identification of canes at the early stages of growth.

The Superintendent visited the Jullundur and Risalewala Sugarcane Stations in the Punjab and Gudiyattam Sugarcane Station in Madras to study the quantitative variations, if any, in the characters of the popular varieties.

V. DISTRIBUTIONS FROM COIMBATORE

(*a*) As canes.

In all sixty-five parcels containing planting material of the new Co. canes and other varieties asked for were distributed to thirty four Provincial and State Sugarcane Research Stations in India for trial.

(*b*) As seeds.

Seeds of the three crosses Co.464 x Co.313, Co.527 x Co.313 and Co.527 x Co. 508 were sent to the Director, Sugarcane Research Station, Shahjahanpur (U. P.) and those of three crosses Co.312 x Co.285, Co.312 x Co.313 and Co.312 x

* The Karnal Sugarcane Sub-Station is financed by the Indian Central Sugarcane Committee.

Co.453, and three General Collections viz., Co.312 G. C., Co.313 G. C., and Co.453 G., C., were supplied to the Sugarcane Specialist, Risalewala, Lyallpur (Punjab).

(*c*) Herbarium Specimens.

Pressed specimens of 'arrows' and leaves of the following ten varieties were supplied to the Director, Royal Botanic Gardens, Kew (England) :— (1) Mungo (2) Saretha, (3) Khagzi, (4) Mankia 31, (5) Uba, (6) *S. robustum*, (7) B. h. V, (8) B. h. IX, (9) G.496, and (10) G.823.

VI. NEW COIMBATORE SEEDLINGS.

The parentages and general characteristics of Co. seedlings distributed to the various Provincial Testing Stations during the year are given below :—

Sl. No.	Co. No.	Parentage.	General Characteristics.
1.	Co.634	P. O. J. 2878 x Co.313	Co.312 class of cane but with better habit. Somewhat soft-rinded.
2.	Co.635	Co.270 x Co.301	A vigorous non-flowering mid-season cane.
3.	Co.636	P. O. J. 2878 x Co.301	A Co.421 class of cane but with much less pith.
4.	Co.637	Co.213 x Co.313	A mid-season cane of fairly good habit.
5.	Co.638	Co.421 x Co.313	An early ripening variety.
6.	Co.639	(P. O. J. 2725 x *Sorghum Durra*) x Co.453	A Co.313 class of cane but with better yield.
7.	Co.640	P. O. J. 2878 x (Vellai x *Sorghum Durra*)	A mid-season cane of satisfactory juice quality.
8.	Co.641	Co.443 x Co.281	A Co.419 type of cane sparse in flowering and not likely to lodge.
9.	Co.642	P. O. J. 2878 x B.3412	Co.421 type of cane but definitely thicker.
10.	Co 643	Co.443 x Co.605	Co.290 type of cane but somewhat thicker.
11.	Co.644	Co.603 x S. G. 63/32	Co.313 type of cane but a heavy yielder.

VII. PROGRAMME OF WORK FOR 1946—47.

Breeding with particular emphasis on specialised characters as 'early' and 'late' maturity, disease resistance, non-pithy character of the stem and chewing quality. Attention will also be paid to evolving Fodder canes.

Cyto-genetical studies with a view to investigating the mode of inheritance of characters in *Saccharum* and allied genera.

Physiological studies on the chemical composition of flowering and non-flowering cane varieties and the initiation of reproductive phase in non-flowering canes by photo period treatments and chemicals.

Seed germination studies with particular reference to viability and the changes brought about regarding chemical and enzymatic characteristics.

The relationship of anatomical and other characters to disease, drought and frost resistance and their inheritance in cane hybrids.

Determination of albuminoids, colloids, etc., in the seedling canes before they are released from Coimbatore.

Survey and collection of the wild forms of *S. spontaneum* and allied genera with a view to taxonomic studies as also for assessing their value as breeding material.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

I. SOIL STUDIES.

1. *Soil survey (1).*—Information collected by the soil survey staff was collated and a report in four parts was submitted to the Imperial Council of Agricultural Research. Most of the members of this staff were absorbed by the Division for carrying out further work as indicated in the report.

2. *A preliminary survey of land for extension of Imperial Veterinary Research Institute.*—(2) 6,000 acres of land at Izatnagar which were intended to be acquired by the Imperial Veterinary Research Institute for a cattle breeding farm were examined and a preliminary survey was carried out. Six pits were examined in the field and samples were collected for analysis. Field moisture of all the pit samples was determined. From the field examination, the soil at Izatnagar appeared to be sandy to sandy loam. The whole area appeared to be of medium quality farm land. Two water samples, one from the well and the other from the irrigation canal were analysed and were found to be good for irrigation purposes. (3)

3. *The study of the soils of the Karnal Farm with reference to the saline and alkaline patches.*—(4) Four pits were examined and soil samples were collected for analysis. Field tests for the presence of chloride and sulphate were carried out and distribution of carbonate within the profiles was studied. The profiles did not show very marked horizon differentiation. A distinction between the horizons could, however, be made on the basis of texture, colour and structure.

4. *Studies on the alkaline patches at Pusa.*—(5) Samples of soil were collected from the alkaline and normal spots in three fields in winter, summer, autumn and again in winter. In winter, samples upto the depth of 1 to 2 ft. were collected, individual samples being obtained according to the colour of different horizons. The samples were analysed for total soluble salts and pH. The results showed that rise and fall of soluble salts in Pusa soil are probably determined by rainfall. Alkaline patches were characterised by high pH and high contents of soluble salts.

5. *Effect of mulch of organic waste material on the movement of salts at Karnal in usar plots.*—(6) From the results of last year's observations it was found that mulching had a beneficial effect in controlling the movement of salts to surface layers. It was also suggested that such a mulch should be removed during rains so that the salts present in the surface layers may be washed or leached out. The study of deeper layers in March indicated that upto 30" there was a regular increase in the salt content of the mulched plot and then there was a sudden fall. Similarly in the unmulched plot there was an increase upto 18" followed by gradual decrease upto 30" and then a sudden fall as with the case of mulched plot.

6. *Extraction of P_2O_5 by citric acid.*—(7) In order to study the limitation of soil water ratio in the method of extraction for determining the available P_2O_5

Note.—Nos. in brackets refer to the persons who worked respective problems.

the soils from Chinsura, Jorhat, Karimganj, Rangpur, Padegaon and Samalkot were extracted by adding 10, 20, 30, 40 and 50 gms. of these soils to 500 cc. of N/5 citric acid and determining the citric acid soluble phosphate after shaking for one hour in each case. The data obtained showed that in the case of the soils studied higher amount of P_2O_5 was obtained when 10 gms. of the soil was taken and the value gradually decreased with increasing amounts of soil reaching a lowest with 50 gms. soil.

7. *Absorption and retention of Ammonia by Indian soils.*—(3) In continuation of the work reported last year ammonia fixing capacities (as defined in last year's report) of 19 soils were correlated with various physical chemical properties of soils like water holding capacity, base exchange capacity, pH and clay content. The relationship can be expressed by exponential equation.

Ammonia fixing capacity constituted a fraction of the base exchange capacity in a majority of the soils examined.

Pot culture experiments with paddy plants showed that nitrogen treatments corresponding to maximum growth of crops followed the order of the ammonia fixing capacities of the soils.

II. AGROCHEMICAL STUDIES.

1. *The movement of P_2O_5.*—(8) Studies were made to examine if the effect of phosphate manuring was due to its creeping into adjacent plots. The samples of soil from the good patches on the side and the central patches of poor growth were taken and examined. Indications were noticeable of slight differences in the exchangeable Ca and some physical properties ; the main physical properties of soil did not show appreciable differences in the good and normal areas. A slight difference was noticeable in the available P_2O_5 by citric acid method ; the P_2O_5 value in the soil samples from the good area showed higher value than that in the adjoining normal area and the centre of the plot. The data were not sufficient to establish a movement of P_2O_5 into the sides of the adjoining plots. The central portion of the plot showed normal growth as the movement of P_2O_5 did not extend upto it as shown by the available P_2O_5 value. These differences are obliterated in the current year's crops.

2. *Nitrogen availability in manures and its bearing on crop production.*—(9) The nitrogen hydrolysed by 80 per cent sulphuric acid considered to be biologically available, by Tiurin Trans. II Comm. 3rd Internat. Congr. Soil Sci. (1933) from manures was found to be correlated with yields and nitrogen recovery by the crop in field experiments treated with the same manures. Better correlation than this was obtained when the hydrolizable nitrogen was extracted after incubation of soil treated with the manures showing that some part of the nitrogen was rendered unavailable and only the remaining was available to the plants. Further the nitrification was directly proportional to the amount of total hydrolizable nitrogen (initial) and inversely to the amount of carbon oxidised during incubation. These two fully accounted for the amount of nitrate formed so much so that the amount of nitrate formed divided by the ratio of sulphuric acid hydrolizable N to carbon oxidised was fairly constant.

3. *The use of ammonium nitrate as fertilizer.*—(6) The effects of ammonium nitrate with different percentages of T. N. T. were studied to assess the manurial value of the ammonium nitrate obtained from surplus ammunition stores which usually contain varying amounts of T. N. T. The direct effects of manuring were reported in the last year's annual report and during this year the residual effects were studied on Maruva (Kagi) crop in Kharif The yield of the crop Maruva, showed that there was no residual effect as was expected since ammonium

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nitrate is a quick acting manure. In rabi 1945-46 a basal dressing of super at 40 lbs. P_2O_5 was given and the effect of ammonium nitrate with 1 per cent., 2 per cent. and 3 per cent. T. N. T. was studied. The results confirmed last year's findings that ammonium nitrate was an excellent manure for wheat (increase in yields 100-125 per cent.) and the presence of T. N. T. up to the extent of 3 per cent had no detrimental effect.

4. *Utilization of indigenous phosphatic manures like bonemeal and rock phosphate in combination with ammonium nitrate.*—(*6*) The results of the Pot-experiments with wheat showed that these indigenous phosphatic manures when used in combination with ammonium nitrate increased the yields than where used singly.

5. *Storage of ammonium nitrate.*—(*6*) Experiments to prevent the cake formation during storage of ammonium nitrate were conducted and it was observed that the material can be stored in paper lined deal wood boxes, after mixing it with 50 per cent of its weight of soap stone powder. The cracks in the exterior of the deal wood boxes should be covered with mud plaster.

6. *Influence of phosphatic fertilizers on soil fertility and crop composition when legumes are included or excluded from the rotation.*—(*10*) Lysimeter investigations were started in winter of 1945 to study the influence of phosphatic fertilizers when applied singly and in combination with N on soil fertility, recovery of nutrients by crops and their yields. Eight lysimeters were filled up with Delhi soil. Following treatments were given—

Experiment A—When legumes are included in the rotation—

Lysimeter No.	I	II
Treatment	No fertilizer	P_2O_5 at 100 lbs./acre
Rotation	Berseem —	cowpeas — wheat.

Experiment B—When legumes are excluded from the ratation—

Lysimeter No.	III	IV	V	VI	VII	VIII
Treatment	No fertilizer.	N at 80 lb.	P_2O_5 at 100 lb. per acre.	N at 80 and P_2O_5 at 100 lbs./ acre.	No fertilizer.	P_2O_5 at 100 lb. per acre.
Rotation	Wheat — Maruva — Wheat					

Soil samples taken before sowing the crop have been analysed for total nitrogen, P_2O_5, K_2O, nitrate nitrogen, available P_2O_5 and K_2O; wheat grain, straw and berseem fodder were analysed for nitrogen, P_2O_5 and K_2O. Carbon dioxide evolution studies were conducted on Delhi soil to determine the manurial requirements of soil.

Carbon dioxide evolution studies clearly showed that Delhi soil was deficient in nitrogen and P_2O_5. The application of nitrogen or P_2O_5 singly would not give full response. In Delhi soil the best results could be obtained when nitrogen and P_2O_5 are applied together, in the case of cereals like wheat.

The carbon dioxide studies further showed that 80 lbs. of nitrogen as sulphate of ammonia and 100 lbs. of P_2O_5 as superphosphate per acre are sufficient when applied singly and the application of N released more P from the soil. In the case of berseem, nitrogen requirements were met by the nitrogen fixing organisms, therefore, the question of application of a com-

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bination of nitrogen and P_2O_5 did not arise. In case of legumes high yield was obtained with P application only.

Crop analysis showed that application of P_2O_5 to berseem enhanced the nitrogen fixing capacity of the root nodule organisms. The percentage nitrogen composition of the untreated berseem and the P treated berseem was the same but the P treated berseem removed as much as 138 lbs. of nitrogen while untreated berseem removed only 43 lbs. of nitrogen per acre. Thus the influence of P fertilization was shown in the recovery and not in the percentage composition in nitrogen. P treated berseem was richer in percentage phosphoric acid composition by 0.2 than the untreated berseem. P treated berseem removed as much as 25 lbs. P_2O_5 per acre while untreated berseem removed only 5.3 lbs./acre. The percentage rise in composition of P_2O_5 was nearly 50 per cent while percentage rise in case of recovery was nearly 367 per cent. Thus the higher recovery of P_2O_5 was not only due to high yield but higher percentage composition also.

K_2O percentage composition of P treated berseem was lower by .7 per cent than the untreated berseem though P-treated berseem recovered as much as 128.5 lbs. in comparison to 48.5 lbs. K_2O recovered by untreated berseem.

The highest N percentage composition in grain was obtained in case of NP- wheat; the rest in order being N-wheat, O-wheat and P-wheat. These figures confirmed the argument that if P_2O_5 was to be applied it should be applied in combination with N in the case of cereals. Here not only the O-wheat was richer in N percentage composition but it had also recovered more nitrogen than P-treated wheat. Same was true of wheat straw also.

In case of P_2O_5 composition same results were obtained, untreated wheat grain being richer in P_2O_5 composition then P-treated wheat. NP-wheat grain was the richest in percentage composition; the rest in order being O-wheat, N-wheat and P-wheat. In case of K_2O O-wheat grain was the richest in composition next in order being N-wheat, P-wheat and NP-wheat. However, due to higher yields NP-wheat and N-wheat recovered the same amounts of K_2O in grain, next in order being O-wheat and P-wheat.

These data are of great interest in this respect that it emphasizes without doubt the point that in case of wheat P must not be applied singly but with nitrogen. Economically it will be of no use because P treated wheat gave only one maund more yield than untreated wheat which gave as much as 22.5 mds. per acre. This difference of one md. in 22.5 mds. may not be statistically significant. At the top of it P treated wheat is poorer in composition than untreated wheat. It is best to apply N and P_2O_5 together, next best being an application of nitrogen only.

7. *Comparison in field experiments of the relative values of nitrogen in green manures, farmyard manure, compost, oilcake and sulphate of ammonia, estimating the recovery of nitrogen by the crop and the changes in moisture, ammonia and nitrate contents of* the soil of different plots: (*11*)

(a) Comparative effects of various organic manures and artificial fertilizers.—In the new and old series during Kharif season (1945-46) the field was fallowed except plots which were to receive green manures and wheat I. P. 165 was taken in rabi in all plots. In the old series alternate blocks were given a dressing of lime at 300 lbs. per acre. All other treatments were same as last year except castor cake which was not applied on account of its unavailability.

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The performances and yield variations, etc. will be dealt with by Agricultural Division in their report; only the chemical investigation carried out by this Division is reported here.

(b) *Evaluation of recoveries of added* P_2O_5 :—While evaluating N recoveries incidentally, P_2O_5 recoveries were calculated. N recoveries were already discussed in last year's report.

The analysis of various manures and fertilizers applied in rabi 1943-44.

TABLE I.

Manures and fertilizers ...	N	P_2O_5	K_2O
F.Y.M. ...	0.53	0.28	0.61
Activated sludge ...	1.34	1.21	0.58
Rape cake ...	5.80	2.09	1.26
Compost ...	0.90	0.23	0.88
Ammonium sulphate ...	20.45	—	—
Superphosphate ...	—	36.13	—
Potassium sulphate ...	—	—	49.22

Table II.

Treatment	Wheat crop, 1943-44 P_2O_5 in the crop per plot in lb.	P_2O_5 in manure per plot in lb.	Percentage Recovery.	1942-43
A. No manure ...	.2235	—	—	—
B. F.Y.M. at 20 lbs.N ...	.2236	.1728	0.06	9.95
C. Act. Slu. at 20 lbs.N ...	.2463	.2954	7.72	15.34
D. Rape cake at 20 lbs.N ...	.2690	.1179	38.60	57.53
E. B Plus (P+K) ...	.2769	.3271	16.33	9.35
F. C Plus ,, ...	.2474	.3271	4.25	16.02
G. D Plus ,, ...	.2761	.3271	16.07	24.67
H. Compost at 20 lbs.N ...	.1884	.0836	42.11	0.25
I. Compost at 10 lbs.N $AmSO_4$ at 10 lbs.N+P ...	.2646	.3271	12.57	13.21
J. F.Y.M. 10 lbs. N+P ...	.3061	.3271	25.25	16.91
K. F.Y.M. at 60 lbs.N ...	.2696	.5184	9.07	11.76
L. N.P.K. ...	.2371	.3271	4.16	15.35

The P_2O_5 recoveries by crop in the different manurial treatments were lower than the previous year's recoveries (1942-43). The P_2O_5 recovery varied from 0 to 38.5 per cent (Rape cake alone had given the highest recovery as

in previous year). F.Y.M. with inorganic nitrogen plus P_2O_5 was next in order The crop absorbed more P_2O_5 as the amount of P_2O_5 in the manure was increased but the increase was not proportional to the amount added. The negative recovery in case of compost and low recovery in case of complete artificial fertilizer is due to low yield in one of the plots of these series.

(c) Evaluation of recovery of added nitrogen.

(i) In 1944-45, no crop was taken in Kharif and wheat I. P. 165 was taken in all plots of old series in rabi. The dose of nitrogen except K treatment was doubled *i. e.* 40 lbs. N was added. In K treatment 80 lbs. N was added instead of 60 lbs. N. Alternate blocks were given a dressing of boron and manganese to see whether minor element deficiency had anything to do with the poor and patchy growth in many plots. But no effect was found though the stand of the crop was satisfactory and there was no lodging in this series.

The details were reported last year by the Agricultural Division in their report.

The dry weight of the crop at the harvest time and nitrogen contents of the crop under each treatment were determined. The total nitrogen content of the crop under various treatments was calculated.

Table III.

Wheat crop, 1944-45 (Old series) Nitrogen Uptake and recoveries.

Treatment	N in crop in lbs.	Diff. from control	N in added manure	Percentage recovery
A. No manure ...	0.95	—	—	—
B. F. Y. M. at 40 lbs. N ...	1.064	0.1134	0.6342	17.88
C. Act. Slu. at 40 lbs. N ...	1.066	0.1157	„	18.24
D. Rape cake „ „ ...	1.311	0.3605	„	56.85
E. 'B' plus (P+K) ...	0.992	0.0422	„	6.65
F. 'C' „ „ ...	1.058	0.1081	„	17.05
G. 'D' „ „ ...	1.095	0.1448	„	22.83
H. Compost at 40 lbs. N ...	0.996	0.0460	„	7.25
I. Compost at 20 lbs. N+$(NH_4)SO_4$ at 20 lbs. N ...	1.161	0.2106	„	23.20
J. F. Y. M. „ „ „ ...	1.249	0.2984	„	47.05
K. „ at 80 lbs. N ...	1.185	0.2351	1.2684	18.54
L. Complete artificials (NPK) ...	1.009	0.0592	0.6342	9.33

The recovery of nitrogen varied from 57 to 7 per cent, the highest being in rape cake alone followed by F.Y.M. + artificial N, lowest recovery was in F.Y. M.+P+K. The addition of artificial N has improved the recovery in both compost and F. Y. M. while (PK) has lowered the recovery in all cases. Artificials

alone had given low recovery, on account of lodging and rust.

The increase of doze of nitrogen in all cases had improved the recovery as compared to previous years. This year the nitrogen content of the crop was much higher than previous years.

(ii) *1944-45*—In the new series started as reported earlier the stand of the crop was satisfactory in the beginning but before maturity the crop lodged badly and there was incidence of rust. The details about the performances of the crop etc. had been reported by Agricultural Division in their last year's report.

The dry weight of the crop at the harvest time and nitrogen contents of the crop under each treatment were determined. The total nitrogen content of the crop under various treatments was calculated.

Table IV.

Wheat crop 1944-45 (New Series) nitrogen uptake and recoveries

Treatment	Total N in crop	Diff. of N from control	N applied in manure	Percentage recovery.
A. G. M. with sunnhemp ...	1.457	0.006	—	0.33
B. „ „ cowpeas K-585 ...	1.474	0.023	—	1.27
C. Rape cake at 40 lbs. N ...	1.597	0.146	1.818	8.03
D. Castor „ „ „ ...	1.605	0.154	„	8.47
E. F.Y.M. „ „ „ ...	1.443	—0.008	„	Negative
F. Compost „ „ „ ...	1.488	0 037	„	2.04
G. Sulphate of ammonia „ ...	1.388	—0.063	„	Negative
H. No manure ...	1.451	—	—	—

As it was not possible to measure the amount of nitrogen added by green manure crop, roots and nodules for the calculation of recoveries of nitrogen, it was assumed that total nitrogen supplied by the tops and roots and nodules was equal to 40 lbs. per acre.

The recoveries of N varied from 0 to 8.5 per cent. The cakes showed the highest recoveries. Sulphate of ammonia and F. Y. M. gave negative recovery.

These low and negative recoveries are due to erratic performances of the block VI. The yields in majority of the plots in this block were abnormally high and if this block was omitted and the results calculated on 5 replication basis the recoveries were much improved as shown by the following table.

Treatment	Total N in crop in lb.	Diff. from control	N in added manure	Percentage recovery.
A. G. M. with sunnhemp ...	1.454	0.122	—	6.71
B. „ „ Cowpeas K-585 ...	1.392	0.060	—	3.30
C. Rape cake at 40 lbs. N ...	1.586	0.254	1.818	17.59
D. Castor cake „ „ ...	1.598	0.206	„	11.33
E. F. Y. M. „ „ ...	1.432	0.100	„	5.50
F. Compost „ „ ...	1.451	0.119	„	6.54
G. Sulphate of ammonia „ ...	1.392	0.060	„	3.30
H. No manure ...	1.322	—	—	—

The recoveries varied from 3.30 to 17.59, the highest being in rape cake followed by castor cake. The least was in sulphate of ammonia. In all the plots receiving sulphate or ammonia the crop was very badly lodged and there was heavy attack of rust. This low recovery may be due to this.

(*d*) *The study of the changes in moisture, ammonia, nitrate and nitrite content of soils of different plots* :—Soil samples from new series were taken 3 times during the year—on 1.2.46, 11.3.46 and 23.5.46. These samples are being examined for moisture, ammonical N, nitrite and nitrate content.

III. MICROBIOLOGY.

1. *Bacteriophage of the root nodule organisms* (*12*).—While growing of lentil for 4 years continuously in the same plot did not produce bacteriophage its growth in the 5th year produced phage. Last year it was observed that while berseem, sweetpeas, peas, and khesari developed bacteriophage in their nodules after they were continuously grown for a period of 2-4 years, lentil and fennugreek failed to develop the specific phage during this period. When the experiment was continued during the 5th year, lentil produced bacteriophage while no phage was produced in fennugreek. These experiments confirm the earlier observation that phage develops when a legume is grown continuously for a fairly long period.

2. *Sulphate reduction and production of elemental sulphur* (*12*).—The pure cultures of these organisms reducing sulphates were maintained and two of these cultures were supplied to Dr. Zo Bell of the California University at his request.

3. *Field experiments with legumes by inoculating the seeds by the specific organisms* (*12*).—Cowpeas K-397 and soyabean chocolate were sown in six replicate plots of 1/40th acre area with three treatments. Organisms K-397 and K-700 for cowpeas and soyabean 1 for soyabean were tried at I. A. R. I. farm and at the Botanical Sub-station, Pusa. Ten experimental plots at this Division were sown with cowpeas K-397. Cowpeas did not benefit much as a result of inoculation both at Pusa as well as at Delhi. The reasons may be due to the fact that the soils of these places are fully saturated with the specific organisms and any more addition of organisms did not result in increase in yield. In the case of soyabean, there was an increase of 9.2 per cent. over control at I. A. R. I. Farm and 5.8 per cent. at Botanical Sub-station, Pusa. It, therefore, appeared that the soils were still unsaturated in respect of this specific organism.

4. *Laboratory experiments with the soil from the experimental plot with respect to total and nitrogen fixing bacterial counts and nitrogen status* (*12*).—These studies consisted of (a) variation of total and nitrogen fixer counts as affected by the growth of legume both inoculated and uninoculated, (b) nitrogen fixation and variation of nitrogen content due to growth of legume and non-legume. While there was a little difference between the inoculated and uninoculated plots in the case of total counts, nitrogen fixer counts were increased as a result of inoculation.

The effect of growth of legumes on the nitrogen status of the soil was demonstrated. The soil originally contained 2.0 mgm. of N per 100 gms. of soil, but due to growth of cowpeas in 1944 it increased to 56.0 mgms. per 100 gms. of soil. There was little difference in the total nitrogen content of the soil due to inoculation.

Further, evidence was obtained as to the effect of the growth of legumes and non-legumes on the nitrogen fixation in soil in the laboratory. While very little or no nitrogen fixation occurred in the samples of soil taken after the

Note.—Nos. in brackets refer to the persons who worked respective problems.

growth of non-legume (mustard) a good deal of nitrogen fixation has occurred in the soil after the growth of cowpeas. It can be concluded from the experiment that apart from the direct gain in nitrogen by the soil due to the growth of legumes, the soil gets enriched in the long run due to fixation of atmospheric nitrogen by the non-symbiotic nitrogen fixing bacteria.

5. *The effect of metals on the fermentation rate of Butanol* (*13*).—The influence of metals on the butanol fermentation of molasses and maize mashes was studied. At a concentration of 0.1 per cent. strips of the following metals were not found to exert any depressing effect :—Iron, magnesium, lead, copper, tin and aluminium. Although lead sheet did not prove harmful, litharge at 0.1 per cent. concentration stopped butanol fermentation. Granulated zinc did not affect the rate of fermentation while zinc dust stopped fermentation in molasses mash although it exerted no toxic effect in maize mash. Thus it appears that the media, the nature and fineness of the metal have pronounced effect in inhibiting the bacterial fermentation.

6. *The effect of stored oil cake on butanol fermentation* (*14*).—Oilcake mildewed in storage reduced the yield of butanol when used as protein source. This adverse effect could be overcome by roasting the mildewed oilcake.

7. *Trial of Mayadas method of composting* (*15*).—The claims of the originators of this method that N is gained in the course of composting could not be confirmed by repeated trials. No nitrogen was gained but a loss of about 1 lb. of nitrogen per 10 lbs. of the original material was noticed. As the Department of Agriculture, U. P., found several defects in the methods of filling the compost pits it was repeated. The pits were filled personally by Mr. N. K. Das from Chaubattia. No gain of nitrogen could be observed this time also.

IV. INSECTICIDAL STUDIES.

1. *Insecticidal work—Marc.*—Last year there was an enquiry from the Master General of Ordnance, about the utility of Marc from Opium. Preliminary experiments were undertaken and the material was subjected to a number of chemical treatments. One of these was found to be effective by the Imperial Entomologist. More material was obtained from the Opium Factory, Ghazipur and the effective preparation was prepared and sent to the Division of Entomology for field trials.

Tabacco (*16*).—In collaboration with the divisions of Entomology and Botany 128 samples of tobacco leaves, and 84 samples of stems were analysed for the nicotine content. The varieties of tabacco analysed were not of any importance from the view point of insecticidal property on account of low nicotine content (leaves 0.88—3.4% and stems 0.46—1.9%). In foreign countries varieties of N. rustica containing 15-20% nicotine have been produced. It appeared that special varieties for production of insecticides required to be evolved

2. *Investigation with flue-cured tobacco* :—As a preliminary to the improvement of the quality of flue-cured tobacco, the chemical changes that occur in the tobacco leaf during this process of curing and their bearing on the quality of leaf were studied.

The main chemical changes in the leaf were disiccation of tissues, hydrolysis of starch and protiens, increase in reducing sugars at the expense of starch, and formation of sucrose which was found to depend on the phosphate content of the leaf.

Note: —Nos. in brackets refer to the persons who worked respective problems.

The quality of the leaf correlated with the initial starch content of the fresh leaf.

V. ROUTINE AND ADVISORY.

The following samples were analysed during the year :—

Soils	28
Manures and fertilizers	15
Water	31
Feeding stuff	30
Grasses	10
Wheat grain and straw	26
Sugarcane juice	78
Tomato	12
Pyrethrum flowers	7
Culture media	1
Tin	2
Fumigated cotton feed	1
Insecticides	6
	247

(a) Of the above samples, 139 came from the Imperial Agriculturist, 20 from the Imperial Entomologist, 17 from the Imperial Economic Botanist, 3 from the Imperial Mycologist and the rest from the Secretary, I.C.A.R., Economic Botanists, Bengal and Assam; Sugarcane specialist, Pusa, Horticulturist, Sambalpur; Director, Locust Control; His Majesty's Consul, Zahidan; Captain R.A.M.C., Imphal ; District Officer, Hangu; Mining Officer, Srinagar; Agricultural Officers, Alwar and Ajmer-Merwara, and Delhi Central Electric Power Authorities. A few items of interest may be mentioned.

(b) Out of the 14 samples of well water which were collected from the wells at I.A.R.I. area, water from 5 wells showed a significant increase in the total soluble solids (bicarbonates, sulphate and chlorides) while in six others there is a tendency to rise, as compared to the salt content in the well water in 1942 (*3*).

(c) 13 samples of sugarcane juice from B.C.R.O.'s experimental plots at Karnal were analysed. The pyrilla-infected canes were compared with the unaffected canes. Some samples were taken by Dr. Leather's method, and some by the random-method suggested by the Statistician. The results of analysis by these two methods of sampling did not exhibit any significant difference.

(d) Six soil samples from the Horticulturist Sambhalpur were analysed and found to be unsuitable for citrus cultivation on account of their low content of total and available P_2O_5 and lime.

Compost Scheme.—The scheme is financed by I.C.A.R. and worked under the guidance of Dr. C.N. Acharya at Nagpur. From 1st Oct. 1945 the scheme was transferred to be worked under the Imperial Agricultural Chemist, at I.A.R.I., New Delhi.

A suitable site was selected near the trenching grounds of the Cantonment Board on the Delhi-Gurgaon Road. Two experimental pits were laid out and dug early in March, and filled up to demonstrate the preparation of town waste compost by the Bangalore Process.

The next item of work taken up was the securing of powerful inoculum of fly-larvae to conduct the fly-control work. Results obtained at Nagpur were corroborated and cow dung was found to be a suitable medium. As this is not available, trials were conducted with slaughter-house waste and offal as an alternative medium and it was found to be quite a good substitute for cowdung.

Collection of seeds of rabi weeds for use in work on the destruction of the viability of seeds in the process of composting was taken up sometime in the month of March 1946. Sufficient quantities of ten common weeds in the fields on the I.A R I. were collected. Twelve pits 2'x2'x1-½' were filled up with an inoculum of weed seeds of ten different plants. 150 seeds of each of the ten varieties were added to each pit, evenly distributed in the layers of refuse materials. The loss of viability of these will be traced with the progress of decomposition. Pits were filled up in June and as yet no data on this point are available.

VI. PROGRAMME OF WORK FOR 1946-47.

Agricultural Chemistry other than soils.

1. Joint field experiments on manurial trials with the Imperial Agriculturist to obtain confirmatory data regarding beneficial residual effect of phosphate manuring of legumes on the subsequent yield of wheat.

2. (i) To study to what level berseem treated with phosphates and followed by guar for 3 years builds up soil fertility.

(ii) To study the effect of heavy doses of complete fertilizers (N, P and K) without legumes in building up soil fertility for comparison with (i) above.

(iii) To compare the effect of introducing a legume like peas in rotation with wheat and maize with the results of (ii) above.

(iv) How to build up soil fertility by means of organic nitrogen in the form of oil cakes and green manures and to study their rate of decomposition under field conditions.

3. The study of the variation of the composition of well waters in the I. A. R. I. area by their periodical examination.

Soil chemistry.

4. Standardisation of methods of soil analysis.

5. Investigations into rapid method of soil analysis.

6. Analysis of soil samples in connection with research projects of other Sections and Divisions.

Soil fertility.

7. Study of the major mineral deficiencies using indicator plants and comparison with other methods.

8. Lysimeter studies—the effect of phosphatic fertilisers on soil fertility.

9. (a) Phosphorus fixation studies in relation to soil fertility and nature of clays in collaboration with the section of Physical chemistry.

(b) To study the rate curves of phosphate solubility of different typical soils with various solvents.

Micronutrient element.

10. Comparison of the microchemical and spectrochemical methods of analysis for trace elements.

11. Diagnosis of minor element deficiencies using indicator plants and injection methods.

12. Effect of micronutrients on the growth and quality of crops with special reference to leaf curl disease of tobacco

13. Study of minor element deficiency diseases with reference to Malta (I C. A. R. Scheme).

Soil Physics.

14. Studies on porespace, pF, water-holding capacity and permeability of typical soils.

Physical chemistry.

15. Studies on soil colour in relation to plant growth.

16. Studies on the chemical, electrochemical and viscous properties of colloidal constituents of soils obtained from different horizons of black cotton soil profile (I. C. A. R. scheme).

Soil Survey.

17. Survey of the Farm areas under I. A. R. I. at Delhi, Pusa and Karnal.

Plant chemistry including soil organic matter.

18. Work on tobacco with a view to finding out nicotine rich varieties of N. rustica.

19. Work on celary.

20. Survey of pyrethrum from different parts of India for determining pyrethrins.

21. Survey of Derris and rotenone containing plants in India.

22. Studies on the organic matter of soil.

23. (a) isolation of humus—identification of constituents.

(b) Organic phosphates.

24. Unfinished work on Cryptostegia.

Microbiology.

25. Fixation or reversion of phosphoric acid through soil micro-organisms.

26. Influence of one crop upon another with special reference to the part played by root secretions and micro-organisms.

27. Nitrogen transformation in soil.

28. Study of root nodule organisms with special reference to inoculation studies.

29. Influence of different doses of phosphates on the formation of nodules and composition of crop (pea and sunnhemp) under field and pot culture conditions.

30. Production of gas from cowdung and farm waste.

31. Stabilisation of the efficiency of butanol organisms.

32. Study of gram wilt disease in collaboration with different sections of this division and divisions of Mycology, Botany and Agriculture.

Biochemistry.

33. Nutritional quality of crop as influenced by manuring.

Tobacco Scheme (*I. C. A. R.*)

34. Studies on the effect of superimposed carbohydrates on the chemical changes during flue-curing and the quality of the cured leaf.

35. Studies on the effect of superimposed nitrogen on the quality and chemical changes during flue-curing of tobacco.

36. Relation between the quality of the different flue-cured varieties and their initial starch content.

37. Comparison of the changes in chemical constituents during flue-curing and sun-curing.

Compost Scheme.

38. Complete control on fly-emergence from compost trenches.

39. Destruction of viability of weed seeds during composting.

40. Destruction of pathogenic organisms during composting.

REPORT OF THE DIVISION OF MYCOLOGY

I. INTRODUCTORY.

During the year under review, it was not possible to carry out fully the programme laid down for the years 1945-47, because of the shortage of staff. The full strength of the sanctioned staff was not available; especially the gazetted staff was much below the sanctioned strength; another factor that put an extra strain on the existing staff was the increase in the number of Post-Graduate students. For these reasons the sub-items (ii), (iii) and (iv) of item I were not investigated.

II. DISEASES OF PLANTS.

(i) WHEAT (*Triticum vulgare*)

1. Loose smut : *Ustilago tritici* (Pers.) Rostrup:—During the year under report 64 varieties evolved by the Imperial Economic Botanist were tested for resistance to this smut. For this work two different collections of the smut, known as L_1 and L_2, were tried. The following results were obtained:—

L_1. Forty nine varieties did not take infection. Ten varieties were up to nine per cent susceptible and five were more than ten per cent susceptible.

L_2. Forty eight varieties did not take infection. Fourteen varieties were up to seven per cent susceptible and two had more than ten per cent susceptibility.

Forty-one varieties have been infected with L_1 and L_2 collections respectively during the present year to see their behaviour during the coming year.

Forty-four varieties of C. P. wheats have been inoculated at Hoshangabad with isolations made from C. P. collection of loose smut. The results will be available next year.

Climatic conditions were not favourable for the incidence of loose smut during the year, even such highly susceptible varieties as Punjab 8A, C518 and C591 were less than 12 per cent susceptible, whereas they are 100 per cent. susceptible in normal smut years. Not much reliance can, therefore, be placed on the results, due to the abnormal climatic conditions that prevailed during the season.

2. Physiologic races :—This work was carried out to determine the physiologic races of loose smut occurring in India. Twenty three varieties were, therefore, infected with loose smut collections number one to ten (L_1 to L_{10}). Due to abnormal climatic conditions, most erratic results have been obtained and no reliance can, therefore, be placed on them or conclusions drawn.

3. Karnal Bunt : *Neovossia indica* (Mitra) Mundkur :—

Infection experiments.—Wheat ears were infected at New Delhi and at Simla with cultures of *Neovossia indica* but none of the ears took infection. Either the cultures had lost their pathogenicity or conditions necessary for successful infection were not favourable. New isolations have been made and will be tested next year.

4. Flag Smut.—*Urocystis tritici* Koernicke :—

Infection experiments.—Seventy-eight varieties were infected with the spores of flag smut and sown to see their reaction to the disease. None of the varieties got infected, apparently due to unfavourable climatic conditions and also to the delay in sowing the seed.

(ii) BARLEY

5. **Covered smut :** *Ustilago hordei* (Pers.) Lagerh :—

Seed treatments.—Infected seeds were treated before sowing with various fungicides. Results are given below :

Treatment	Total No. of plants	Total No. of diseased plants	Percentage of disease	Yield in lbs.
A Control	7618	2128	27·93	173·72
B Sulphur	8300	20	0·24	177·82
C Baluchistan Sulphur	8038	16	0·18	193·13
D Copper Carbonate	9211	11	0·12	175·77
E Agrosan G	8554	7	0·08	180·38
F Formalin Dust	8236	2	0·02	178·33

(iii) JOWAR (*Sorghum vulgare.*)

6. **Long smut :** *Tolyposporium ehrenbergii* (Kuhn) Pat.—One hundred ears of jowar were infected with cultures of *Tolyposporium ehrenbergii*. A suspension of the culture was placed in the rubber bulb of an atomiser to which a No. 20 hypodermic needle was attached. The ears were then inoculated with the suspension at various stages of their growth, that is from the time they are formed within the sheath to their emergence and again before, during and after flowering. None of the ears got infected.

7. **Grain smut :** *Sphacelotheca sorghi* (Link) Clinton :—

Seed treatments.—Smut covered jowar seed was treated with various seed dressings before sowing. The results are tabulated below :

Treatment	Total No. of ears	Total No. of smutted ears	Percentage of disease	Yield in lbs.
1. Control	19113	1241	6·4	20·14
2. Sulphur dust	16923	1	0·0	20·0
3. Baluchistan Sulphur	16675	1	0·0	24·0
4. Agrosan G	19458	3	0·0	25·3
5. Copper Corbonate	19292	0	0·0	26·0
6. Formalin dust	17258	27	0·1	22·6

(iv) PIGEON PEA (*Cajanus cajan*).

8. **Wilt**: *Fusarium udum* Butler.—Twenty-two varieties received from the Imperial Economic Botanist were tested for resistance to this disease. I. P. 90 and I. P. 41 have been found to be resistant in the last three years' trials.

9. **Canker**: *Diplodia cajani* Ray Chaudhury.—The incidence of this disease was negligible.

(v) GRAM

10. Several diseases of gram have been described from time to time, such as gram wilt, gram foot-rot ; various causes have been found to be responsible for these diseases ; but the resulting symptoms have not been so far clearly described, so that the cause of the disease may be recognised from the symptoms ; for this reason a detailed study of the symptoms of the diseases and their causes as found in Delhi and Karnal has been undertaken. Different disease symptoms were noted, such as bronzing of leaves, premature shedding of leaflets, yellowing of the plant from top downwards, complete wilting of the whole plant, wilting confined to a few branches. From some of the diseased plants collected at Delhi and Karnal no pathogenic organism could be isolated ; from some of the plants collected at Delhi the following organisms were isolated.—*Fusarium* sp., *Rhizoctonia solani, Sclerotinia sclerotiorum,* bacteria and nematodes.—from collections made at Karnal the following organisms were isolated : *Fusarium* sp., *Operculella padwickii* and bacteria. It is of interest to note that no case of *Operculella padwickii* was obtained this year from Delhi though in previous years this fungus had been readily isolated from diseased gram plants.

From diseased plants that showed bronzing the following organisms were isolated. *Rhizoctonia solani, Operculella padwickii,* and nematodes. In some cases no organism was isolated from plants showing bronzing.

From plants that showed premature shedding of leaflets nematodes were found infecting the roots.

From plants that showed yellowing from top downwards no organism was isolated.

From plants that showed complete wilting *Operculella padwickii* and *Fusarium* sp., were isolated.

From mature plants having only a few branches that were wholly or partially dead bacteria were isolated from the diseased branches.

Bacteria and nematodes have been for the first time isolated from diseased plants.

The organisms isolated from diseased gram plants will be used next season for inoculating gram plants to study the symptoms of the disease produced by each of them.

(vi) POTATOES (*Solanum tuberosum* L.)

11. **Late blight**: *Phytophthora infestans* (Mont.) de Bary.—Late blight appeared on the potato crop at Kufri (Simla Hills) about the third week of July, 1945 ; this naturally infected material was used as inoculum for testing the

resistance or susceptibility of potato hybrids and cultures raised by the Imperial Economic Botanist, at the Potato and Wheat Breeding Sub-Station, Simla. Twenty-two hybrids were found to be resistant and 60 were found to be susceptible. These results show that most of the varieties which were found to be resistant in previous years continued to be resistant. The resistant varieties 83-D, 126-D, 127-D, 135-D, 178-D and 166-D will not be further tested. A few varieties which had proved to be resistant in previous years were found to be susceptible in last year's trials. These varieties will be further tested along with other varieties required by the Imperial Economic Botanist.

So far resistance to foliage has been tried; some of the varieties which have shown foliage resistance will be tried for tuber resistance.

Phytophthora infestans has been taken in culture.

At Kufri another *Phytophthora* sp. was isolated from potato tubers collected from plants showing symptoms similar to those of late blight. This *Phytophthora* is a new species and is under study.

At Simla and on hills below Simla, another *Phytophthora* has been found to attack the foliage of potato plants. It causes a distinct wet rot of leaves; its symptoms are entirely different from those of late blight. The incidence of this disease is earlier than that of late blight. This fungus has been isolated and is under study.

12. **Early blight:** *Alternaria solani* (*E. & M.*) *Jones and Grout.*—The Plant Pathologist to the Government of United Provinces suspected that tubers from early blight infected plants carried the infection in them and that use of these tubers as seed may be a potential source of infection the following season. At his request experiments were laid to see if the infection was carried by the tubers. He supplied a large quantity of some different varieties of tubers collected from early blight infected crops. These tubers were planted in Delhi. Their germination was normal and they gave a healthy crop.

At Simla two distinct types of symptoms were observed on leaves affected by early blight. In one case the necrotic area was a well marked brown spot with a definite outline; in the other case the diseased area was not sharply delimited from the healthy area; it was "blotchy" in appearance and rather blackish in colour; whether these two types of symptoms are due to different races or strains of the fungus or due to the different varieties of the host, requires to be investigated; isolations from these two types of symptoms have been made and there is no morphological difference in the fungus, *Alternaria solani* isolated from them. Plants raised at Delhi from potato cultures 83 and 256 supplied by the Imperial Economic Botanist from the Potato and Wheat Breeding Sub-station, Simla, were inoculated with these two isolates. The infected leaves showed the blotchy type of the early blight symptom. The same isolates were used for inoculating tomato plants and they produced the blotchy type of infection. Further work on these isolates is in progress.

13. Resistance of potato tubers to infection by some important fungi found under storage conditions:—

Twenty-two varieties of tubers supplied by the Imperial Economic Botanist from Simla were tested. *Fusarium solani, Rhizoctonia bataticola* and *Rhizoctonia solani* which are known to be specially responsible for storage rot of tubers were used for these tests. Inoculated tubers were kept under moist conditions for three months. S. 80 and Na. 86 did not take the infection with any of these three

fungi. None of the varieties was found to be susceptible to all the three fungi. The results are given in the table below:

		Fusarium solani.	*Rhizoctonia bataticola.*	*Rhizoctonia solani.*
Culture	11	—	+	—
,,	115	—	+	+
,,	256	+	+	—
,,	259	—	—	+
,,	296	—	+	—
,,	298	—	+	—
,,	307	—	+	+
,,	324	+	—	+
,,	327	—	+	+
,,	335	+	+	—
,,	388	+	—	—
,,	398	—	—	+
,,	403	—	—	+
S	80	—	—	—
S	47	—	+	—
Na	86	—	—	—
(CXB)	5	—	—	+
Hybrid	2	+	+	—
,,	5	—	—	+
,,	9	+	+	
,,	12	—	—	+
,,	13	+	—	—

14. **Virus diseases of potatoes**:—Plants of potato varieties *Darjeeling Red Round, Gola, Up-to-date* and *Phulwa* showing different disease symptoms such as veinal necrosis, crinkle, foliar necrosis, etc., were tested for their virus content with the help of suitable differential hosts. *Solanum viruses I, II* and *III* were invariably found to be present either singly or in mixture with each other. *Solanum virus VI*, a closely related virus to *Solanum virus I* was recovered for the first time from potato plants of *Phulwa* variety.

15. **Seed Potato Certification** :—The annual inspection of the potato crop in Kumaon, Chakratta Hills and Simla Hills was made as usual. In the areas examined in the Kumaon Hills the negligible types of mosaic were most common, the incidence was about 55 to 70 per cent; but the incidence of severe types of mosaic was from 2·5 to 23 per cent. The observations made this year in June are similar to those made last year in June. In Chakratta Hills the incidence of negligible types of mosaic was between 24·5 to 46 per cent and of the severe types of mosaic was from 8 to 20 per cent. In the Simla Hills the negligible types of mosaic varied from 24 to 47 per cent. In Patna and Bihar Shariff in Bihar the incidence of negligible types of mosaic ranged from 42·5 to 75 per

cent. In Bihar Shariff the incidence of the severe types of mosaic was 0 to 8·0 per cent in the crops raised from local seed whereas in the crops raised from seed obtained from Patna the range of variation was between 9 and 13 per cent. In Patna the incidence of the severe types of mosaic was up to 40 per cent. In the plains of the United Provinces Phulwa raised from seed obtained from Farukhabad was found to be highly infected by the severe types of viruses; in some cases the infection was as high as 90 per cent ; but in the *Phulwa* crop raised from seed obtained from Patna the incidence of the severe types of mosaic was rather low; for example in about 25 acres only four per cent of the crop was infected.

Testing in the insect-proof house.—In the absence of a suitable insect proof house only a limited number of tubers of different varieties could be tuber-indexed and tested on differentials for freedom from diseases in the improvised insect-proof house of the Mycology Division. Tubers of varieties *Gola, Majestic Numbri,* pure *Up-to-date* and *Darjeeling Red Round* were indexed. The material thus tested has been planted at the Central Station at Kufri.

Selection in the field.—Preliminary selection of apparently disease free plants of *Phulwa* variety of potatoes growing in the field were made. No apparently disease free material of *Gola* variety has yet been obtained. It was observed on testing that almost all the apparently healthy plants of *Phulwa* variety carried a weak strain of *Solanum virus* I. It is therefore, proposed to multiply *Phulwa* material as such after testing for other viruses in the insect-proof house.

General

(a) During the selection of suitable *Phulwa* plants a disease causing necrotic spots on leaves was commonly observed in some selections. The virus causing the disease has been indentified to be *Solanum virus* VI.

(b) Preliminary observations seem to indicate that dust storms, rain or leaf contact may be the agencies which transmit *Solanum virus* I.

16. *Potato Seed Multiplication :—*

The scheme during the year under report was divided into two parts : (1) One part of the scheme consisted in planting twenty-five acres at Karnal by the Imperial Agriculturist. The agricultural operations were under his control, this Division was responsible for roguing out diseased plants and storing the produce in cold storage. (2) The other part of the scheme consisted of purchasing twenty five acres of cultivators' crops in low incidence areas after making a survey of different potato growing tracts.

(1) Karnal :—*Darjeeling Red Round* was planted in an area of 8·5 acres and *Phulwa* in 16 5 acres. There was a heavy frost for a few days in December which caused considerable damage to the crop. The potato fields were one patch of brown. Fresh growth was put forth after the crop was given several irrigations; the tuber formation was very much delayed and at the time of harvest (March-April) they were immature and naturally of poor keeping quality.

The crop was systematically examined throughout the season and plants showing severe types of diseases were rogued out. The yields of tubers from *Darjeeling Red Round* and *Phulwa* were 245 and 1921 maunds respectively.

Shortly after harvest *Darjeeling Red Round* tubers began to rot in the store room; they were unsuitable for storage as seed.

Phulwa tubers also seemed to be of doubtful keeping quality ; soon after harvest a major part of it had begun to rot. Only 883 maunds were ultimately available for storage in the cold store at Meerut.

(2) *Cultivators' crops.*—The potato crop in the important potato growing localities in the United Provinces and Bihar was examined for disease incidence.

Bihar : The disease incidence in Patna area where *Phulwa* variety is extensively cultivated, was generally more than 20 per cent ; but in some small plots, each having an area of about 1/5 to 1/10 of an acre, the disease incidence was low and varied from 5 to 10 per cent. In Bihar Shariff area, *Phulwa* had not been extensively cultivated during the year under report. *Phulwa* plots were small, about 1/5 to 1/10 of an acre each, and were scattered-over a wide area. The disease incidence in these plots was low, about 1 to 8 per cent. Most of the second crop in this locality had been planted late. In these areas it was not possible to purchase reasonably large blocks as the holdings were small; and the few places in Bihar Shariff area where suitable plots were available, they were far away from each other.

United Provinces : In Meerut and Hapur areas the disease incidence in the *Phulwa* crop raised from seed obtained from Farukhabad was very high; in certain cases it was over 60 per cent but the disease incidence in the *Phulwa* crop raised at Hapur from one lot of three wagons of seed obtained from Patna was rather low; this crop had also escaped damage by frost. The holdings in this area were small but were larger than those in Bihar and more conveniently situated. The disease incidence during the first observation in most of the crop varied from about three to five per cent.

About 21 acres of the crop having an incidence of disease up to about 5 per cent was purchased from the cultivators on yield basis. The minimum price of well sorted, unbruised seed size potatoes was fixed at Rs. 6/2/- per maund. After roguing out from time to time diseased plants from these 21 acres, 3109 maunds of graded potatoes were stored in the cold store. Out of 3109 maunds 2750 maunds were stored in the Hapur Cold Store and 359 maunds were stored in the Meerut Cold Store. There was no loss due to rotting in the material raised at Hapur.

The cultivators were paid compensation for the rogued out plants on the basis of 100 plants yield at the time of harvest.

The seed obtained from the Karnal crop last year was supplied to the Director of Agriculture, Bihar (100 maunds), Director of Agriculture, United Provinces (400 maunds), Director of Agriculture, Jaipur (10 maunds), Director of Agriculture, Baluchistan (40 maunds). The Deputy Director of Agriculture, Patna Range, Patna, reports that the yield of potato from Karnal seed was 209 maunds per acre at Bihar Shariff ; and at Sabour was 100 maunds per acre, the average yield being 166 maunds. He says, "The general yield of the crop raised from Karnal seeds compares favourably with the local seeds planted by the growers. The percentage of severe type of virus affected plants in the registered plots was 3.5 against 20 to 25 per cent of severe type of virus affected plants found in the plots of the growers planted with local seeds. The mixture in the registered plots sown with Karnal seeds was 0.37 per cent only, which is negligible." Reports from the United Provinces, Jaipur and Baluchistan regarding the performance of the seed supplied from Karnal have not been received till the time of writing this report.

(vii) TOMATOES (*Lycopersicum esculentum* MILL.)

17. (a) A disease showing necrotic rings caused by a virus on tomatoes was observed for the first time during the year under review.

(b) On account of severe frosts the tomato crop was badly damaged and therefore no results could be obtained from the experiments planned on a field scale for the control of virus diseases.

(c) The effect of high humidity on disease incidence was studied by growing tomato plants in plots covered by thatches on three sides. High humidity in the covered plots was maintained by spraying water frequently throughout the day. Records of disease and insect incidence were maintained. The results indicated that there was a marked fall, *i. e.*, about 34 per cent in the disease incidence in these plots. Insect incidence was also compartively low in them.

18. *General.*

It was confirmed that Melon mosaic virus is seed transmitted. A short note in this connection was published in the Current Science.

Observations on the occurence of virus diseases of plants were made. The following diseases were observed :

1. Phyllody, mosaic and enation mosaic in sunnhemp.
2. Yellowing in brinjal.
3. Mosaic and malformation of cowpea.

Experiments on the mode of transmission and study of properties of the above viruses are in progress. Study of pathological histology has been undertaken.

(viii) SUGARCANE (*Saccharum officinarum* L.)

19. **Red-rot :** *Colletotrichum falcatum* Went.—As desired by the Government Sugarcane Expert 24 cane varieties which he considered to be important for his work on cane breeding were tested for resistance to red rot by inoculating them with isolate No. 78 of *Colletotrichum falcatum* Went. Judging from the linear spread of the infection three varieties, Co. 349, Pansahi and Chunee were found to be fairly resistant, the spread of the infection being less than 15 inches; three varieties, Co. 312, 244, and 233 were highly susceptible, the infection having travelled upto 40 inches and the remaining 17 were moderately susceptible, the infection having extended from 15 to 30 inches.

An year old compost made from cane affected by red-rot was applied in the furrows before they were planted with highly susceptible varieties like Co. 213, 233, 299, 331 and 445 ; the resulting crop was healthy.

20. **Physiologic forms of the red-rot fungus** :—The light coloured, highly sporulating isolates have been again found to be more virulent than the dark coloured isolates ; but there are a few exceptions.

21. **Smut** : *Ustilago scitaminea* Sydow :—Varietal resistance tests were continued as in previous years. The results of these tests will be consolidated when sufficient reliable data become available regarding the reaction of the varieties to smut infection.

III. TAXONOMY

22. **Rusts** :—Studies on Indian rusts were continued. A new rust on *Grewia papulifolia* collected at Rohtak was named *Catenulopsora grewiæ* Mundkur. *Crossopsora premnæ* (Petch) Syd. on *Premna tomentosa*, collected in Mysore, and *Uromyces scillarum* (Grev.) Winter on *Hyacinthus* sp., collected at Quetta, are new records for India. As a result of detailed examination, *Uromyces gentilis* Syd. and *Uromyces aulicus* Syd. have been transferred to the genus *Scopella*. A monograph on the rusts of India is under preparation.

23. **Smuts** :—Work on the smuts of India was continued. The smut collected on *Cyperus difformis* in Kodaikanal is a new species of *Sphacelotheca*, and is named *S. cypericola* Mundkur. *Entyloma compositarum* Farlow on *Lactuca decipiens* collected at Bangalore is a new record for India. The smut on *Alisma reniformis* collected in Mysore is described as *Burrillia alismacearum* Mundkur nov. spec. This genus has not so far been recorded in India. Specimens of smut affected *Cynodon dactylon* collected in Mysore did not agree with those of *Ustilago cynodontis* P. Henn., but agreed with *U. hitchcockiana* Zundel ; this is also a new record for India. A monograph on the *Ustilaginales* of India is under preparation.

24. **Phyllosticta** :—The Indian species of this genus were studied. There are at present twenty-six species represented in India, of which six species have been found to be new to science, and fifteen are new records for India. A monograph on this genus has been completed.

25. **Miscellaneous fungi** :—*Oidiopsis* on linseed has been named *Oidiopsis lini* Mundkur. *Oidiopsis taurica* var *macrospora* Uppal, Patel and Kamat has been renamed *O. macrospora* (Uppal et al) Mundkur and Thirumalachar comb. nov. The following are new records for India :—

Peronospora spinaceæ Laubert on *Spinacea oleracea, Daldinia albezonata* Lloyd on burnt rhizomes of *Saccharum munja, Linosora ochraceæ* (Desm) Sacc. on leaves of *Pyrus malus; Massaria mori* Miyake on *Monis alba ; Nitschia fuckelii* Nitschke on *Salvadora oleoides; Tryblidaria azaræ* Urries on *Punica granatum; Tryblidiella rufula* (Spreng.) Sacc. on *Diospyros montana* ; *Rhytisma salicinum* (Pers.) Fries on *Salix tetrasperma; Ascobolus magnificus* Dodge; *Peziza badia* Persoon, both on ground.

IV. ADVISORY.

26. Advice on mycological and pathological problems from Provinces and States were complied with. Information regarding literature and descriptions of fungi were supplied when asked for.

V. INDIAN TYPE CULTURE COLLECTION OF FUNGI.

27. During the year under review 160 new acquisitions have been added to the collection. A number of doubtful authenticity and origin have been removed from the collection. At present there are 678 cultures of which 140 are of *Phycomycetes*, 226 of *Ascomycetes*, 93 of *Basidiomycetes*, 205 of *Deuteromycetes* and 14 of Bacteria.

One hundred and fifty-seven cultures were supplied to University Professors and research workers and industrialists, in India and abroad. Cultures of fungi used in fermentation processes and in the development of anti-bacterial substances were in great demand.

VI. HERBARIUM

28. Nine hundred and forty-seven specimens were added to the Herbarium during the year under review. A set of 26 fascicles of Exsiccati "Fungi Dakotensis" by J. F. Branckle containing 715 specimens was purchased for the Herbarium. Twelve specimens of "Myriangiales Selecti Esxiccati" by A. E. Jenkins and A. A. Bitancourt were received.

Thirty-seven specimens for our collection have been kindly supplied by Dr. Thirumalachar (Mysore); Mr. G. S. Kulkarni (Gwalior), Dr. Padwick (Bengal), Dr. Uppal (Bombay), Mr. Thomas (Madras) and Dr. U. B. Singh (United Provinces); the thanks of this Division are due to these Mycologists for their gifts.

VII. PROGRAMME FOR 1946-1947.

I. Plant Pathological investigations :—

i. Physiologic specialisation and modes of transmission of some cereal smuts (loose smut, flag smut and bunt of wheat, long and head smuts of jowar, other smuts).

ii. Studies in antibiosis and bacteriostatic and fungistatic substances with special reference to plant pathogens.

iii. Studies in fungicides on a laboratory scale.

iv. Study of suitable spray and dusting machinery.

v. Testing the disease resistance of crops evolved at the Indian Agricultural Research Institute.

vi. Potato diseases : Viruses ; selection of virus free material ; tuber indexing ; certification ; multiplication of disease-free seed tubers ; early and late blight ; potato storage rots.

vii. Tomato virus diseases.

viii. Sugarcane diseases with special reference to parasitic specialisation in the red-rot organism.

ix. Miscellaneous diseases.

II. Mycological investigations :—

i. Taxonomy of fungi with special reference to rusts, smuts and the genus *Fusarium*.

ii. Maintaining the Indian Type culture Collection of fungi.

iii. Advisory work on mycological problems; identification of fungi received from the Provinces and States.

III. Miscellaneous :—

i. Maintaining a Host-index of fungi.

ii. Preparation of card-indexes of species of fungi represented in India.

iii. Maintaining an up-to-date card-index of literature of plant pathology and mycology.

iv. Training of post-graduate and other students.

REPORT OF THE DIVISION OF ENTOMOLOGY

I. REPORT ON INVESTIGATIONS.

1. Discovery and control of insect vectors of virus diseases.

(*a*) *Field-scale trials* :—A survey of the host plants of the white-fly, *Bemisia tabaci*, vector of tobacco leaf-curl disease, revealed the following plants to be some of its important hosts :—

Sida rhombifolia, Solanum nigrum, Hibiscus sabdarifa, Euphorbia spp., tomato, chillies, 'bhindi' and cruciferous crops.

Experiments conducted to transmit leaf-curl disease from tobacco to papaya gave positive and interesting results; the incubation period of the virus on this host was as long as 10 months, whereas from papaya back to tobacco the virus took only 3 weeks.

Spraying experiments with fish-oil rosin soap, in the proportion of 1 : 160 parts of water, were conducted at the Tobacco Breeding Station, Nipani (Bombay Presidency). Out of four experimental plots, far apart from one another, two were sprayed first when about two months old and subsequently sprayed four times at an interval of a week. The initial incidence of leaf-curl varied from 5% to 20% in these plots, and the spraying operations ultimately saved 11% to 28% of the plants as compared with those in the untreated plots.

In an experiment in collaboration with the Imperial Agricultural Chemist, tobacco plants grown in pots and given various manurial treatments were exposed to infection of leaf-curl disease. There was no disease in plants treated with either P or K, while in the case of other treatments, P+N, P+N+minor elements, and farm yard manure, the disease was found in varying degrees.

(*b*) *Survey of sucking types of insects* :—Among the sucking types of insects collected from various crops, the more important known vectors were *Empoasca* spp., *Myzus persicae* and *Aphis gossypii* on 'bhindi', tomato, potato and brinjal which also exhibited symptoms of virus attack.

2. Insect population studies.

Studies on insect populations have been pursued under two different lines, viz., (A) Development and standardization of technique, and (B) Study of the population fluctuation of the spotted bollworms of cotton in relation to climatic and biotic factors.

The Development and standardization of technique has been followed under (a) Statistical, and (b) Biological aspects. The statistical aspect of the work is intended to give the necessary mathematical precision in recording the data. In recording observations on population census the misleading nature of percentage incidence has been already shown. It has also been pointed out that for the population estimation of the spotted bollworms of cotton in a unit area of 1/40 acre, 5-7 random plants will form a suitable sample. But, it is not so far known whether there is any differential zonal distribution of this pest in a large field of cotton and whether the selection of a few plots of the above size at random for census observations will suffice to give a correct estimation of the population of the whole area. A set of precision experiments have been devised to elucidate these points.

Under Biological aspects the following have been tackled :—

(*a*) *Explorations into the dynamics of Insect development : (1) in relation to temperature* :—A preliminary comparison of the values of the pupal periods of

Earias fabia observed during the course of field rearing with the values obtained by the use of five different equations proposed by different investigators, has been made. The nearest values to the observed data have been obtained by the use of the equation

$$Y_{(t_1-t_2)} = \frac{Yo\left[e^{x_2 \quad ax^2}_{x_1}\right]}{t_1-t_2}$$

proposed in the course of the present investigations. (ii) *In relation to physiological age* :—An experiment has been devised to see whether development proceeds uniformally or not, if the external factors likely to affect growth are kept constant as far as possible. (iii) *In relation to food* :—Some preliminary observations taken on larvae of *Earias* spp. fed separately on hollyhock and cotton did not present any appreciable difference in their pupal periods. (*b*) *Biometric estimation of the developmental periods of Earias fabia* :—(i) Computation of the daily biothermic values for the pupal period with the help of pupal biometer and thermograph records has been continued as a matter of routine and comparison of the estimated values with the data collected by rearing during the year has been made. (ii) A method of predicting the pupal period, by means of biometer and the thermograph record of a previous typical year for the corresponding period is being perfected. (iii) As a fair amount of data regarding the egg and larval periods have been collected through field rearings, endeavours have been made to prepare egg and larval biometers. The necessary calculations for this have been completed and an egg-biometer is ready for use.

The study of the population fluctuation of the spotted bollworms of cotton being our main long-range programme, this work has been pursued under two different lines :—(*a*) *Collection of the data necessary for population study,* viz., (1) record of the population fluctuation of the spotted bollworms and their parasites from an experimental area of 2.5 acres of cotton at Karnal by a regular process of field census supplemented by field rearing, and (2) record of such meteorological factors as temperature, humidity, rate of evaporation, rainfall, etc. which might have contributed towards fluctuations of population. (*b*) *Study and interpretation of phenomenon of population fluctuation* :— Although data has necessarily to be collected over a long period for a correct interpretation of population, from preliminary studies of the data collected so far, a relation between the logarithm of weekly population (Y), average temperature of the week (x) and the number of the week after cotton sowing (z), expressible by the equation : $Y = Ax^2 + Bx + Cz^2 + Dz + E$, has been envisaged. Attempt has been made to fit this equation to the data obtained during the year 1943—44 and the values of the constants A, B, C, D, and E have been elucidated.

3. Pests of stored food-stuffs.

(i) *Pests of 'jowar'* :—For the control of pests of stored 'jowar', a number of chemicals were tried. It was found that the dose of DDT and 666 when reduced to even 1 : 40,000 killed adults of five important pests (*Sitophilus oryzae* Linn., *Rhizopertha dominica* Fabr., *Tribolium castaneum* Hbst., *Corcyra cephalonica* Staint., and *Sitotroga cerealella* Oliv.) and stopped further infection for a period of eight months without affecting the germinating capacity of the grains. These two chemicals, however, did not prove effective when mixed with lime and used as a wash along the sides of the grain containers. Mercury used as loose metal, dispersed in chalk or as an amalgam, gave complete kill of the eggs of *Corcyra cephalonica*. Preliminary experiments with air charged with mercury showed that eggs of *C. cephalonica* are killed in 5 minutes. Fumigation with carbon bisul-

phide at the rate of 6 lbs., 4 lbs. and 2 lbs. per 1000 c. ft. killed the adults of the above mentioned 5 important stored 'jowar' pests in 6 hours, 12 hours and 36 hours respectively during summer, but in winter months complete kill was obtained with the 6 lbs. dose in 18 hours and with 4 lbs. in 24 hours ; a dose of 2 lbs. did not kill these pests even in 48 hours. Observations were made to study the influence of air-tight *versus* well ventilated condition on the incidence of pests. The results, although inconclusive, indicated that grain having low moisture contents stored in air-tight conditions whether kept in moist or dry atmosphere, would not be favourable for breeding, while under well-ventilated conditions only moist atmosphere encourages breeding.

(ii) *Pests of dry fruits* :—A survey of the insect pests of dried fruits was made from material procured locally and from different provinces, viz., N.W.F.P., Baluchistan, Madras, and the Punjab. The most common pests were (1) *Oryzaephilus mercator* Fauv. on walnuts, cashew-nuts, apricots, pistachio-nuts, and cocoanuts (copra); (2) *O. surinamensis* Linn. onraisins, figs, persimmon and prunes ; (3) *Plodia interpunctella* Hub. on walnuts and pistachio-nuts ; (4) *Ephestia elutella* Hub. (?) on apricots, (If confirmed, it will be a most important first record from India) ; (5) *E. cautella* Wlk. on apricots and figs ; (6) *Corcyra cephalonica* Staint. on cashew-nuts and persimmon ; (7) *Tribolium castaneum* Hbst. on almonds and groundnuts, and (8) *Stathmopoda* sp. (hitherto not recorded from India) on black figs, pears and peaches. *Ephestia* sp. and *Plodia* sp. were observed parasitised to a great extent by *Microbracon hebetor* Say. This work has been undertaken by a post-graduate student owing to lack of staff.

(iii) *Pests of stored pulses* :—As a result of a preliminary survey thirteen different insects were found infesting stored pulses. Of these, four species—*Bruchus chinensis* Linn., *B. analis* Fabr., *B. affinis* Fabr. and *B. pisorum* Linn.—were observed to be the most important. At Delhi during harvest time, peas showed 7% attack by *B. pisorum* and 'arhar' and cowpeas from 8% to 12% respectively by *B. chinensis* and *B. analis*. 'kesari' and 'masur' were less susceptible and these suffered slight attack by *B. chinensis* only. Of the chemicals tried as preservatives, copper carbonate at the rate of 1 : 200, sodium fluosilicate at 1 : 1500, and DDT and 666 at 1: 40,000 gave complete kill of the above mentioned Bruchids and prevented subsequent infestations. Fumigation trials with carbon-bisulphide and hydrocyanic acid gas showed that the former applied at the rate of 4-5 lbs. per 1000 c. ft. at 62°—71° F, and the latter at the rate of 1½ ozs. per 100 c. ft. at 83°—87° F with 24 hours exposure gave complete kill of adults, larvae and pupae of all these Bruchids.

4. Survey of Icerya purchasi.

A thorough survey of this pest was made at several selected centres in Assam, Bengal and Bihar provinces, where *Aleurites fordii* one of the host plants found in several countries and another allied species, *A. montana*, are grown. Although a number of scale insects were collected from these plants, this pest was not recorded from any of the localities visited. The survey of this pest was continued as usual in Madras Presidency, Orissa and Mysore State during the greater part of the year and it was recorded from Bangalore, Hessargatta Krishnarajasagar and Vibhutipura in Mysore State. The pest was found on *Casuarina eqouestifolia* and *Pyrus malus* in all the localities and in addition on *Citrus* spp., at Bangalore. Three new species of *Icerya* were recorded during the course of these surveys. Among the natural enemies, two species of *Rodolia* and a pyrallid caterpillar, *Euzophera cocciphaga*, were found; the latter has been recorded for the first time from this host.

In all the localities surveyed for *Icerya purchasi*, careful examination of the known host plants of San Jose Scale, *Quadraspidiotus perniciosus*, was carried out. This pest was recorded on apple, plum, peach and pear at Shillong and Sonapani in Assam, at Kalimpong in Bengal and at Pollangi in Orissa, for the first time. This pest was also found to attack apples at the Fruit Research Station, Hessargatta in Mysore State, and apple bush at Panchgani in Bombay Presidency. A parasitic fungus, *Microcera coccophila*, was recorded on this pest at Kalimpong in Bengal.

5. BIOLOGICAL CONTROL OF PESTS OF SUGARCANE.

Trichogramma colonisation field experiments : Cuttack (Orissa) :—In June, 1945, the egg parasitisation of the stem borer, *Argyria sticticraspis* in the six liberations blocks was 14.3%, in the twelve liberations blocks 30.65% and in the control 4.17%. The maximum egg parasitisation of 95% was observed in September in one of the experimental plots. The parasitisation in the control plot was 23.4% during the same period. In December the parasitisation in the six liberations blocks was 53.35%, in the twelve liberations blocks 88.12% and in the control only 3.83%. These figures show that the stem borer can be fairly controlled if parasites are distributed effectively and timed to achieve maximum parasitism by careful observations of the life cycle and the oviposition period of the stem borer moth *Argyria sticticraspis* in the field.

In June, 1945 *Argyria sticticraspis* damaged 32.37% of the shoots in the six liberations blocks, 25.87% of the shoots in the twelve liberations blocks and 41.06% of the shoots in the control. At the time of harvest *Argyria sticticraspis* damaged 15.35% of the canes in the twelve liberations blocks and 29.45% of the canes in the control.

Larval and pupal population of *Argyria sticticraspis* was 283.3 per acre in the six liberations plots, 216.65 per acre in the twelve liberations plots and 616.65 per acre in the control plots.

The average yield of cane at the time of harvest in the six liberations blocks was 597.25 maunds in the twelve liberations plots, 716.0 maunds and in the control 440.7 maunds p r acre.

1946-47 experiments —Six blocks, each of 3.5 acres were laid out at Banki in December and these were planted with Co. 421. The parasitisation before the commencement of liberations was 5.9% in the experimental blocks against 15.15% in the control. There will be no pre-and post-monsoon liberations this season and succeeding season as decided in the Entomological sub-committee. There will be continuous releases till the larvae enter into hibernation with a short interval during the monsoon. *Argyria sticticraspis* damaged 3.57% of the shoots in the experimental plots against 3.10% in the control. Further parasite liberations, stem borer examination and borer population studies are in progress.

A critical study of three years results at Motihari, Cuttack, Nellikuppam and Walchandnagar showed that, though there was in each of these four centres no perfect correlation between the egg parasitisation, borer population, and the yield, there was an unmistakable trend that the parasite *Trichogramma* can to some extent control the damage by the stem borer and the root borer (when the latter is a pest) and increase the yield.

The *Pyrilla* parasite conservation experiments were repeated in Karnal during the year under report. On account of heavy rains in July and August, the population of *Pyrilla* dwindled to a low proportion when compared with a normal year. Hence it is very difficult to come to any definite conclusion on the

basis of population counts. It may however be observed that in the conserved plots the parasitisation rose from 21% before conservation to 35.72% after conservation. In the non-conserved plots the parasitisation was 18.87% and 18.87% during the same two periods. In the control, the parasitisation figures were 16.77% and 13.52% These figures show that the conservation of parasites may prove to be effective for the control of *Pyrilla*. The experiments are being repeated.

The biology of *Epipyrops melanoleuca*, a parasite of potential importance for the control of *Pyrilla*, was studied in the laboratory where the daily maximum temperature fluctuated between 78°F. and 90°F., the minimum from 69°F. to 83°F. and humidity from 38% to 72%. The parasitic moth lays on an average 500 eggs, though one female was observed to lay as many as 1,500 eggs. The newly hatched larvae which are very active attack nymphs of all instars of *Pyrilla* though generally they prefer the 3rd instar. They cling to the leg and afterwards move to the thoracic region where they suck the contents of the nymph. The adults are attacked in the abdominal region. The life-cycle is completed in about 31 to 34 days.

During the year under report 5,02,416 *Corcyra* moths, 1,702.1 c. c. eggs and about 22.5 million *Trichogramma* parasites were bred in the parasite laboratory.

It was observed that at a constant temperature of 25°C. and relative humidities of 45%, 50% and 55 % the longevity of the parasite was 48, 48 and 51 hours respectively. It was also observed that at the same constant temperature as above and relative humidities of 60%, 80% and 90% the parasite lived for 5, 6 and 7 days when fed with 10% sucrose solution; while the unfed parasite lived for only 48, 54 and 58 hours respectively.

Fecundity studies at a constant temperature of 25°C. and relative humidities 60%, 80% and 90% showed that 22, 47 and 30 *Corcyra* eggs were parasitised by a fertilized female when fed on 10% sucrose solution. The corresponding preimaginal period was 9 days under all humidities.

The maize stem borer, *Chilo zonellus* was found to be a very suitable and useful alternate host for the Braconid parasite *Stenobracon deesae* Cam., which parasitises the larvae of the root borer (*Emmalocera depresseila*), the stem borer (*Argyria sticticraspis*) and the top borer (*Scirpophaga nivella*). At 25°C. and average relative humidity of 68% a single parasite was observed to parasitise twelve *Chilo zonellus* caterpillars. The wax moth larva, *Galleria mellonella*, which can easily be bred in large numbers in the laboratory was tried as an alternate host for the parasite at 25°C. and 68% relative humidity. Though the parasite was induced to lay eggs on the larvae kept in split canes and the eggs hatched into larvae, the latter did not complete their life-cycle. The experiments are being repeated as *Galleria* can be a very useful alternate host.

6. Termite and their control.

A thorough survey of the termite fauna was made in the environs of Delhi ; the species found were *Cyclotermes obesus, Microtermes anandi, Microcerotermes heimi, Eremotermes paradoxalis* and *Coptotermes heimi*. The last named species was found for the first time at Delhi and was very rare. *Cyclotermes obesus* in all its three allied forms (a, b and c) was the commonest termite and was found attacking sugarcane setts, wheat plants and a number of trees. *Microtermes anandi* was also common and found attacking sugarcane setts and wheat plants, besides grass and dry wood.

A number of experiments were conducted with a view to prevent termites from attacking wheat and sugarcane. Wheat seeds treated with 5% DDT solution or 50%DDT dust prior to sowing were not attacked. Likewise wheat sown in plots treated with 1.19% solution of DDT at the rate of 336 gallons per acre before sowing was not attacked. Chemical analysis of the wheat plants showed that those attacked by termites contained 24.5% sugars whereas the unattacked ones contained 20.5% sugars. Dipping of sugarcane setts in 5% DDT solution or in a solution of lead arsenate and lime in water in the proportion of 1:10:40 kept them safe from the attack of termites ; there was also no attack of termites in plots treated with 0 24% DDT solution applied at the rate of 336 gallons per acre before planting. There was some attack of termites on wheat and sugarcane in plots treated with 4.7% of Dithane solution at the rate of 336 gallons per acre prior to their sowing. Wooden rods treated with 20% solution of Anti-Mortal-Antaxo were found to be attacked by termites although it is claimed by the manufacturer that the above strength of this chemical makes the wood immune to white-ant attack.

7. Insecticides and fumigants.

Studies on the insecticidal properties of opium and tobacco initiated last year were continued.

A 5% solution of dilute acetic acid extract of opium marc gave a mortality of 40% to 80% against, *Utetheisa pulchella*, *Epilachna 28-punctata*, *Aulacophora foveicollis* and *Myllocerus* spp. by the dipping method in the laboratory. Larvae of *Corcyra cephalonica* proved more resistant, undergoing a mortality of 30% to 50% with the above strength. Under field conditions the mortality was lower. The same solution sprayed against *Bagrada picta* on mustard and *Utetheisa pulchella* on *Heliotropium* sp. gave a kill of 20 to 35%. Psyllids infesting 'phalsa' plants, however, underwent 95% mortality by a single spray of the same strength. In addition to its effect as an insecticide, observations indicate that opium marc, has strong repellant action against certain species, e.g., *Myllocerus laetiverens* and *Poecilocerus pictus*. These insects left the sprayed host plants more or less completely.

The Nicotine contents of different tobacco varieties raised by the Imperial Economic Botanist were determined by the Imperial Agricultural Chemist and their insecticidal properties were investigated in this laboratory against *Bagrada picta* adults and larvae of *Corcyra cephalonica* and *Bombyx mori*. It has been observed that the leaves as a rule possess more nicotine and bring about higher mortality than the stems and branches. The maximum nicotine content of leaves was 3.42% and of the stem 1.83%. The maximum mortality of *B. mori* obtained with standard decoction of leaves was 100% and with that of stems, it was 86%.

Standard decoction of leaves and stems tested on *Bagrada picta* adults gave mortality upto 80% with varieties having 3% to 3.5% Nicotine content, 53% to 70% with varieties having 2.5% to 3% Nicotine, 46% to 50% with varieties having 1.5% to 2% Nicotine and so on. There is also indication that the Nicotine content and insecticidal power of samples taken from the field on 30th April, 8th May and 24th May progressively increased as they approached maturity. Further tests on a larger scale are being arranged to confirm this view.

8. Control of house-flies and mosquitoes.

Systematic survey of the house-flies occurring in the neighbourhood of the Institute was conducted and adequate control measures applied throughout the year. The commonest species of house-flies found were *Musca nebulo* and *M. vicina*.

All the mosquito breeding places on the estate and in its vicinity were properly oiled, while in wells used for drinking water the fish *Gambusia sp.* was added. In one of the wells Gammexane No. D025 was periodically used and it was found that at the rate of about 6 ozs. per 100 sq. ft. surface, it kept the well free of mosquito breeding for 2 weeks during the active breeding season. Owing to these concerted measures of control the colony was practically free from house-flies and mosquitoes.

9. Insect pests of potatoes.

A survey of the fauna of potato crop carried out in the estate revealed a number of injurious insects, the more important of which were *Myzus persicæ, Aphis gossypii, Creontiades pallidifer, Empoasca* spp. and *Campylomma livida.* In view of the vast importance of the potato tuber moth, *Gnorimoschema operculella* to potato cultivation in India, some biological observations on this pest were carried out. Investigations were also undertaken on the possibility of controlling this pest by means of one of its larval parasites, *Microbracon gelechiæ,* imported for this purpose from Canada. The first problem was the evolution of a technique, under Indian conditions, for the mass multiplication of this parasite. In view of the ready availability of *Corcyra cephalonica* as laboratory host, attempts were made to utilise it for the new parasite. Encouraging results have been obtained and a fairly satisfactory method for the mass breeding of the parasite has been developed. Preliminary laboratory experiments with the parasite have produced heavy parasitisation of larvae of potato tuber moth and thus shown its vast potentialities in controlling this pest.

10. Observations on Indian insects of economic importance.

(*a*) *Record of insect pests of crops*:—Detailed surveys of the insect pests of crops were conducted throughout the year within and in the vicinity of the estate. Of over 200 insects found associated with various crops, the following were present in a pest form :

Acanthiophilus helianthi and *Macrosiphum solidagenis* on Safflower ; *Agromyza obtusa* and *Lampides boeticus* on *Cajanus cajan ; Agrotis* spp. on gram and potatoes ; *Amsacta moorei* on maize, cowpeas and sann-hemp ; *Antigastra catalaunalis* on sesamum ; *Bagrada picta* and *Rhopalosiphum psuedobrassicæ* on cruciferous crops ; *Chilo zonellus* on maize and 'jowar' ; *Dichocrocis punctiferalis* on castor ; *Earias fabia, E. insulana* and *Platyedra gossypiella* on cotton ; *Etiella zinckenella* on peas ; *Hypera medicagenis* and *Lygaeus pandurus* on lucerne ; *Leucinodes orbonalis* on brinjal ; *Myzus persicæ* and *Nysius inconspicuus* on tobacco ; *Plusia nigrisigna* on gram ; *Phyllocnistis citrella* on citrus plants ; *Scirpophaga nivella* on sugarcane ; *Utetheisa pulchella* on sann-hemp and *Heliotropium* sp. (a weed) and *Aulacophora foveicollis, Chætodacus cucurbitæ,* and *Epilachna* spp. on cucurbits. Besides these. some other pests, such as *Heliothis armigera, Luperodes* sp., *Myllocerus lætiverens, M. maculosus,* and *Phytomyza atricornis* were very common on a number of field crops.

(*b*) *Watch over insects likely to assume pest status* :—*Earias cupreoviridis,* a serious pest of cotton in China, was again found in large numbers only on a wild weed, *Sida* sp., near about the Institute. It was confirmed that this insect hibernates for about six months, in the pupal stage, from about the end of October to the beginning of April, but at higher temperatures of 30°C. and 27°C. generation after generation can be bred during winter months. It appears likely that hibernation is mainly brought about by the fall in temperature and that humidity, which is generally very low both at the time of hibernation and at the time of emergence of moths, does not play any important part. Some observations made show that low temperatures acting on the larval and not the pupal stage bring about hibernation. Larvæ bred

at 30°C. were transferred when full-fed to 21°C. where they pupated in a day or two and moths emerged from them after a fortnight or so. Similarly from the freshly formed pupae transferred to 21°C. from 30°C. emergence of moths took place. On the other hand pupæ bred from larvæ kept at 21°C., when transferred to a high temperature took longer to emerge as moths as compared to pupæ reared from the larvæ at high temperature. Further, the fact that it was possible to rear 3 generations, one after the other, very successfully on cotton suggests that the insect may at any time turn its attention to cotton crop in this country.

During the year under report *Nysius inconspicuus*, an insignificant pest so far, has been observed in large numbers breeding on the capsules of tobacco impairing the vitality of seeds. Likewise *Peizodorus rubrofaciatus* on lucerne and larvæ of *Porthesia xanthorrhœa* on many crops were observed in unusually large numbers damaging the plants. An interesting chalcid (yet unidentified) has been found making galls on the fruits of *Sesamum indicum*. It is suspected that the same chalcid breeds on two other common plants, *Sesbania aculeata* and *Tribulus* sp.

11. Immature stages of Indian Insects.

Studies on the immature stages of Indian insects were continued. Of the pests studied, *Piezodorus rubrofasciatus* on lucerne, *Porthesia xanthorrhœa* and *Serica* sp. on several crops deserve special mention. Among predatory insects, life histories of *Coranus spiniscutis*, *Harpactor marginatus* and *Harpactor costalis* were worked out. Coloured plates presenting the life-histories of these insects have also been prepared Certain obscure points in the biology of a number of insect pests, whose life histories are at present only partly known, have been elucidated. The more important of these are *Ergolis merione*, *Phycita clientella*, *Scymnus* spp. *Chilomenus sexmaculata* and *Lema* sp.

12. Predators and parasites.

A number of predators were recorded on several important pests. The common predators were *Coccinella septempunctata*, *Chilomenes sexmaculata*, *Coranus spiniscutis*, *Brumus suturalis*, *Harpactor* spp. and *Laius* sp. and they were generally observed feeding on aphids. *Rodolia* sp. was found feeding on coccids. Among the parasites observed, special mention may be made of an internal parasite, *Alophora* sp. (?) attacking adults of *Bagrada picta*. This parasite has been recorded for the first time from this host. Three pupal parasites of *Utethesia pulchella* were also recorded probably for the first time. Two of these belong to genus *Brachymeria* and the third one is possibly a species of *Sturmia*. The incidence of *Brachymeria* spp. on *Utetheisa* pupæ was very heavy in May and June, 1946 and at times as many as 40% of the pupæ were parasitized. A braconid parasite, probably *Microbracon* sp., has been recorded on *Marasmia trapezialis*.

13. Taxonomic studies of insect groups of economic importance.

(*a*) *Parasitic Hymenoptera*:—Systematic studies on this group were continued and five new species have been discovered, *viz.*, (1) *Amonadontomerus indicus* sp.-n., (2) *Diomorus indicus* sp.-n., and (3) *Monobæus indicus* sp-n., belonging to Torymidæ and (4 *Apanteles crocidolomiæ* sp.-n., a parasite of *Crocidolomia binotalis* and (5) *Apanteles euprocticiphagus* sp.-n. parasitic on *Euproctis lunata*. Further studies on parasitic Hymenoptera have been slightly interrupted due to change of staff.

(b) *Isoptera*:—The taxonomy of this group was taken up and a good deal of work has been done towards the preparation of a catalogue of the Indian species. Further work will be undertaken by the recently introduced school of research.

(c) *Other groups* :—A study of the Indian Acriididæ was taken up during the year with the primary object of preparing a catalogue which is urgently needed due to the scattered nature of the literature on this group. Two new species, one a curculionid, *Pachyonix menoni* sp.-n. and the other, *Hoplolomia delhiensis* sp.-n., a coreid, have also been described.

14. Imperial Pusa collection.

During the year 128 specimens comprising 53 species of Diptera, 100 specimens comprising 10 species of Rhynchota, and 845 specimens of Curculionidæ consisting of 113 species were registered and card-catalogued. 142 species of insects were added to the collection of which 49 were not so far represented. 6 species of insects received as donations, 2 from Major Strainton of General Headquarters, Delhi, 2 from the Entomologist, Icerya purchasi Scheme, and 1 each from the Entomologist, Lac Research Institute, and the Director, Indian Central Jute Committee were also added to the Collection. In all 160 species of named insects were sent out as donations, 104 to the Principal, Polytechnic Institute, Delhi, 33 to Secretary, Boy Scout Association, Simla, 12 to the Director, Zoological Survey of India, 9 to the Director of Agriculture, Jaipur, and 1 each to the Director, Imperial Institute of Entomology, London and to the Director of Indian Tea Association, Assam.

II. ADVISORY WORK

285 species of insects received from various parts of India were identified.

Nearly 100 enquiries received from different parts of the country were attended to and the requisite information supplied.

Control measures against several insects species appearing in serious form both in the Institute and outside were undertaken.

Three papers were examined in detail and reported upon regarding their suitability for publication.

III. PROGRAMME OF RESEARCH WORK OF THE ENTOMOLOGY DIVISION FOR THE YEAR 1946-1947.

I. *Discovery and control of Insect Vectors of the Virus Diseases of Indian crops* :—(i) Field-scale trials of sprays for the white-fly vector of tobacco leaf-curl disease will be made in co-operation with some Provincial Entomologists. (ii) Survey of the sucking types of insects of other economic crops particularly potato.

II. *Insect Population Studies* :—(i) Development and standardisation of technique of population study. (ii) Study of fluctuation of populations of spotted bollworms in relation to biotic and climatic factors, (as per programme approved by the Imperial Council of Agricultural Research).

III. *Pests of stored Food-stuffs* :—(i) Experiments on the control of pests of Jowar will be continued and special attention will be paid to fumigation and inert dusts, (as per programme approved by the Imperial Council of Agricultural Research.) (ii) Work on the control of dry-fruit pests will be continued and special attention will be paid to the method of heat-sterilization of infested material. (iii) Pests of stored Pulses, similar to work on Jowar pests, (as per programme approved by the Imperial Council of Agricultural Research).

IV. *Biological Control of Pests of Sugarcane* :—Field trials with *Trichogramma* and detailed study of other potential natural enemies, (as per programme approved by the Indian Central Sugarcane Committee).

V. *Termites and their Control* : —Systematic and biological studies and control work of termites common in Delhi and Karnal.

VI. *Insecticides and Fumigants* :—Trials of known insecticides like DDT and 666 and fumigants and work on insecticides made from indigenous materials, particularly tobacco and waste products in opium manufacture.

VII. *Control of House-flies* :—Field-scale trials of various methods.

VIII. *Insect Pests of Potato* :—Particular attention will be paid to the potato moth and the potato jassids and potato aphids.

IX. *General observations on Indian insects of economic importance* :—Keeping records of the seasonal occurrence and abundance of those insects found associated with crops. Vigilant watch for insects assuming or likely to assume pest status.

X. *Immature stages of Indian insects* :—Studies of immature stages of Indian insects and their mode of damaging crops.

XI. *Predators and parasites* :—General biology of promising parasites and predators of insect pests of India.

XII. *Standardization of technique for fumigation of imported fruits against codling moth* :—(As per programme approved by the Imperial Council of Agricultural Research).

XIII. *Taxonomic studies of insect groups of economic importance* :—Studies on Indian Parasitic Hymenoptera, particularly Ichneumonidæ, Diptera of Agricultural importance (Agromyzidæ, Trypetidæ and Tachnidæ), Rhynchota, particularly Aphididæ and Isoptera will be conducted.

XIV. *Imperial Pusa Collection* :—Building up and maintenance of a reference collection of insects of India.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

The work of the Division was on a very restricted scale, due to non availability of financial assistance and lack of qualified personnel. Most of its work was confined to the no small task of maintaining and keeping in service the dilapidated and obsolete implements and machinery of the Agricultural Division which task was made more difficult through lack of spare parts, raw materials, machine and hand tools.

Most of the time therefore, day to day requirements, carried out solely in connection with the control of materials, maintenance of implements and machinery and manufacture have tended to obscure longer terms activities.

A complete scheme for the future expansion of the Agricultural Engineering Division was drawn up and submitted to the Government of India in conjunction with I. A. R. I. expansion scheme for 1946-47.

The Agricultural Engineer acted as Member and Secretary of the Government of India *Kans* Control Committee and was responsible for the general layout and all mechancial operations of the *Kans* Control experiments now being undertaken near Bhopal for which a monetary grant of Rs. 40,000 was sanctioned to cover the first year's work.

It is hoped to submit an interim report of the first findings of the experiment early in 1947.

Research projects and work generally has been of necessity very curtailed. Schemes and projects have however been considered and planned, which can there, fore, when finance, staff and other facilities become available, be put quickly into operation.

Small research has been made into water-lifts, country and inverting ploughs-sub-soilers, etc. and scope for their modification and improvement will be continued. Experiments are in progress to consider the scope of disposal vehicles in regard to their utilization, suitability and actual performance as prime movers in tillage operation and other farm usages. It is hoped to submit this report for publication within the next two months; coincident with the disposal to the public of such vehicles and to anticipate the marketing of a new Agricultural Jeep, now in course of production in U.S.A.

Experiments have been carried out in the design of a new subsoiler or soil aerator, suitable for bullock draught and the first of these implements is now in course of manufacture.

Work on the modifications of 'Victory' and similar ploughs with regard to improved type of 'hitch' and hand control both suitable for bullock draught with a resultant improvement in performance is also in hand.

Major work carried out by the existing workshop include, the overhall and repair of cold rooms, plant, equipment situated in the Division of Entomology, installation of new pumping sets in the Dairy etc.

With sanction for extensions and facilities the programme for 1946-47 will be expanded; such expansion will however depend on the progress at which anctioned expansion can be effected, i. e., new buildings, recruitment of qualifi-

ed staff, and procurement of machinery, tools, hand tools and raw materials. A certain proportion of the activities of the existing and new staff will be directed towards the development and organisation of the Division in its initial stages.

It is proposed however to expand, develop and encourage the submission of new ideas, or modification to existing implements, machinery or processes for manufacture and trial in the experimental stage ; to encourage also, commercial manufacture of Agricultural Implements etc. to send their products for trials and report.

Facilities for the repair and organised maintenance of machinery and plant within the Institute will also be extended.

It is proposed to increase the number of research projects including one into the possibilities of conservation by drying both by mechanical and natural methods, or the continuation of both, of grass and other fodder crops.

APPENDIX I.

Gazetted staff of the Institute.

Director ...	Dr. J. N. Mukherjee, C.B.E., F.N.I., F.R.A.S.B., F.C.S.	
Asstt. Director ...	Dr. B. P. Pal, M.Sc., Ph. D. (Cantab.), F.L.S.	
Personal Assistant to the Director ...	Mr. A. M. Desai.	
	Agriculture.	
Imperial Agriculturist ...	Mr. C. H. Parr, B. Sc., I.A.S.	
Agricultural Experimentalist ...	Mr. R. D. Bose, B.Sc. ..	The post is temporary; it was held by Mr. Bose throughout the year except for the period 8th May to 13th July 1946 when he officiated as Secretary, Indian Central Sugarcane Committee.
Assistant Agriculturist ...	Dr. A. G. Riaz, B.Sc. (Ag.), Ph. D. (Wales).	
Statistician ...	Mr. P. V. Krishna Iyer, M.A.	
Assistant Agronomist ...	Mr. S. Sen, M.Sc. ...	From 21-12-45. The post is temporary. Mr. Sen held charge of the current duties of the post of Agricultural Experimentalist during the absence of Mr. R. D. Bose on foreign service.
Farm Superintendent, Karnal ...	Mr. A. R. Khan, B.Sc. (Ag.).	
Cattle Superintendent, Delhi	Mr. N. P. Fernandez, G. B. V. C.	
Cattle Superintendent, Karnal ...	Mr. J. D. Sampatkumaran, L.V.P.	
	Botany.	
Imperial Economic Botanist ...	Dr. B. P. Pal, M.Sc., Ph. D. (Cantab.), F.L.S.	
Second Economic Botanist ...	Dr. S. Ramanujam, M.A., Ph.D. (Lond.).	
Plant Physiologist ...	Dr. R. D. Asana, M.Sc., Ph.D. (Lond.). ...	From 21-3-1946. The post is temporary.
Assistant Economic Botanist ...	Mr. R. B. Deshpande, M.Sc. (Ag.) (Offg.).	
Second Assistant Economic Botanist ...	Dr. J. J. Chinoy, M.Sc., Ph. D. (Lond.).	
Assistant Botanist ...	Mr. A.B. Joshi, M.Sc. ...	From 11-1-1946. The post is temporary.
Superintendent and Potato Research Officer, Potato Breeding Station, Simla ...	Dr. Pushkar Nath, M.Sc., D.Sc.	On deputation to Cambridge for six months from 24-4-1946.

Assistant Botanist (Geneticist), Potato Breeding Station, Simla ...	Mr. M. L. Khanna, B.Sc.	The post is temporary.
Superintendent, Botanical Sub-Station, Pusa ...	Mr. S. M. Umar, B.Sc.	
Superintendent, Tobacco Breeding Sub-Station, Guntur ...	Mr. T. Narayana Rao, B.Sc (Ag), M.A. ...	The post is temporary.

Agricultural Chemistry and Soil Science.

Imperial Agricultural Chemist ...	Vacant.	
Second Agricultural Chemist Incharge Division of Soil Science and Agricultural Chemistry ...	Dr. S. V. Desai, B.Sc., D. Sc., (Lond.). ...	The post is temporary.
Organic Chemist ...	Dr. R. H. Siddiqi, M.Sc., Ph. D., D. Phil. (Oxon.) ...	The post is temporary.
Soil Survey Officer ...	Dr. S. P. Raychoudhury, D.Sc., Ph. D. (Lond.) ...	Officiating.
Assistant Agricultural Chemist ...	Dr. S. Das, M.Sc., D.Sc.	
Assistant Agricultural Bacteriologist ...	Vacant.	
Second Assistant Agricultural Bacteriologist ...	Mr. A. C. Ukil, M.Sc.	
Assistant Chemist ...	Dr. W. V. Balsunder Rao, B. Sc., Ph. D. ...	From 10-1-1946. The post is temporary.
Assistant Soil Survey Officer	Dr. R. V. Tamhane, M.Sc., Ph. D. (Lond.) ...	(Offg).
Assistant Soil Survey Officer	Dr. S. K. Mukherjee, M.Sc., Ph. D. ...	Officiating.

Entomology.

Imperial Entomologist ...	Mr. P. V. Issac, M.Sc. ...	(Officiating). Up to 31-10-45.
Second Entomologist ...	Dr. Taskhir Ahmed, B.Sc., Ph.D. (Cantab). ...	Officiating. Placed in-charge of the Division in addition to his own duties from 31-10-45.
Biological Control Research Officer, (Sugarcane Pest Scheme) ...	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. ...	The post is temporary.
Assistant Entomologist ...	Mr. H. Haroon Khan, B.Sc. (Hons.) (Lond.) ...	Officiating.
Second Assistant Entomologist. ...	Mr. B. B. Bose, B.Sc. ...	Officiating.
Assistant Entomologist ...	Dr. S. Mukherjee, D.Sc. ...	From 13th July, 1945. The post is temporary.
Assistant Entomologist (Population Studies). ...	Dr. S. Pradhan. ...	Upto 9th January, 1946. Dr. Ram Das Menon, Ph. D., from 19th January 1946. The post is temporary.

Entomologist, Pulse Scheme	Mr. C. N. Modawal, M.Sc. ...	From 17th September, 1945 The post is temporary.

Mycology.

Imperial Mycologist ...	Mr. J. F. Dastur, M.Sc. (Lond), I. A. S. (Retd.) ...	Officiating.
Second Mycologist ...	Dr. B. B. Mundkur, M. A., Ph. D. (Iowa). ...	The post is temporary.
Seed Potato Production Officer..	Dr. R. S. Vasudeva, B. Sc., Ph. D. (Lond.), D. F. C. ...	The post is temporary.
Assistant Mycologist ...	Dr. B. L. Chona, Ph.D.	(Offg.).
Assistant Mycologist (Temporary) ...	Vacant.	
Assistant Plant Pathologist ...	Mr. S. P. Ray Choudhuri, M.Sc. ...	From 25th April, 1946. The post is temporary.

Agricultural Engineering.

Agricultural Engineer ...	Major D. T. Brown. A. M. I. Mech. E. M. I. B. A. E. ...	From 31st October, 1945. The post is temporary.
Assistant Engineer ...	Mr. A. K. Kaul, L.E.E. ...	From 31st October, 1945.

Sugarcane Breeding Station, Coimbatore.

Sugarcane Expert ...	Mr. N. L. Dutt, M.Sc.	
Second Cane Breeding Officer ...	Dr. N. Parthasarathy, B.Sc., (Agri.), Ph.D. (London).	
Assistant Surgarcane Expert	Mr. M. K. Krishnaswami, M.A.	
Plant Physiologist ...	Mr. N. D. Yusuf, M.Sc., (Cantab.) ...	The post is temporary.

APPENDIX II.

Training of Students and Research Workers during 1945-46

(a) *Awarded Post-graduate Diploma of the Institute.*

Name of Student	*Subject of thesis.*
	Botany
1. Prem Shanker Parsai B.Sc. (Ag.) (Nagpur) ...	Part I—Self and Cross—Incompatibility in Diploid and Tetraploid Toria (*Brassica* campestris L. Var. Toria) with special reference to pollen tube growth and seed setting.
	Part II—The Whole-Mount Method for the study of Embryogeny of *Sesamum Orientale* L.
	Part III—Megasporogenesis, Megagametogenesis, Endosperm and Embryo Development in *Sesamum Orientale* L. and some observations on crossability between Diploid and Tetraploid Races of *Sesamum Orientale* L.
2. Malik Hukam Chand B. Sc. (Ag.) (Punjab) ...	Influence of the environment on yield and variation in plant characters in wheat.
3. Mohd. Jamil Khan M.Sc. (Aligarh) ...	Comparative study of the Morphology and anatomy of Sesamum species, an autotetraploid and an amphidiploid.
	Chemistry
4. B. R. N. Iyengar B.Sc. (Mysore), B.Sc. (Ag.) (Poona) ...	Study of the soil-fertility status as reflected by crop yields in the direct and indirect manuring of wheat.
5. J. K. Jagtiani B. Sc. (Ag.) (Poona)	The Effect of Fertilizers on Soil Fertility, Yield, Composition and quality of crop.
	Mycology
6. M. S. Pavgi M.Sc. (Benares) ...	Part I—A third contribution towards the knowledge of Indian Ustilaginales.
	Part II—Preliminary observations on some viruses causing diseases in cucurbits.
7. G. C. DaCosta B.Sc. (Ag.) ...	Part I—The Genus Phyllosticta in India. Part II—A Study in Yeasts.
8. K. R. Chowdhury B.Sc. (Calcutta) ...	Part I—Nature of Resistance to Loose Smut in some wheat varieties.
	Part II—The genus Uromyces in India.
	Sugarcane Breeding
9. Ghulam Yazdani B.Sc. (Ag.) ...	Part I—Sugarcane Breeding at Coimbatore.
	Part II—The relationship of certain morphological characters to lodging in sugarcane.
10. Jagannath Hota B.Sc. (Ag.) (Nagpur) ...	Part I—Studies in Pith and cavity of sugarcane, with a brief reference to those in some important allied genera.
	Part II—Sugarcane Breeding at Coimbatore.

(b) *Awarded Post Graduate certificate in Agriculture.*

1. Luxmi Narain Raizada.	B.Sc. (Ag.)
2. Makhdum Nazir Ahmed	"
3. Sukhraj	"

4.	Banta Singh Dhillon	B.Sc. (Ag.)
5.	Abdul Ghafoor Khan	,,
6.	Vaddi Rama Rao	,,
7.	Sibte Mehdi Naqvi	,,
8.	Shyam Lal Bhatnagar	,,
9.	Chaturbhuj Narain Singhal	,,

(c) *Post Graduates under training during the year.*

Agriculture.

1. Madan Mohan Jain.
2. Syed Ali Asghar Shah.
3. Mohd. Charag Dogar.
4. Dalip Singh.
5. M. G. Ponnappa.
6. P. M. Kochappa Menon.
7. Mahendra Pratap Singh.
8. Gir Raj Kishore.
9. Sunilendu Sen.
10. Gajendra Rout.
11. Kailash Narain Sharma.
12. Thamba Pillai Valauthan.
13. D. A. Veerasinghe.

Sugarcane Breeding.

14. Shahabuddin Fasihi.
15. Sury Krishnanand Sastry.
16. Ahmed Mustafa Khan.

Botany.

17. Shree Ram Bhargava.
18. Bhawani Shanker Joshi.
19. W. T. Butany.
20. Abdul Rahman Memon.
21. Sohan Lal Tandon.
22. G. Venkataratnam.

Chemistry

23. Suresh Prasad Gupta
24. Jitendra Ramanlal Desai.
25. D. P. Mohiramani.
26. Narain Patnaik.
27. Kishannath Synghal.
28. D. V. Krishna Rao.
29. Parmeshwar Sinha.
30. Kalidas Sen Gupta.

Entomology.

31. Govindananda Sharma.
32. Tej Pal Singh Teotia.
33. Mohd. Rashid Khan.
34. K. A. Kazi.
35. G. Narasinha Rao.
36. M. Fazal Dad Khan.
37. G. Ranga Ayyar.

Mycology.

38. B. D. Mundkur.
39. Khwaja Salabat Ali.
40. Rajpal Singh Nirwan.
41. T. K. Nariani.
42. R. C. Patnaik.
43. Mohd. Sarwar.
44. J. Samraj.
45. Upendranath Verma.

Plant Protection. (One year course)

46. H. S. Aggarwal.
47. Om Parkash Kohli.
48. S. G. Patil.
49. Abdul Hamid.

(d) *Students admitted for short course of training.*

	Student	*Subject*	*Period*
1.	M. Mumtaz Ali (Delhi)	Botany	1 month.
2.	U. R. Hathiramani (Bombay)	Mycology	1 month.
3.	Dr. R. S. Choudhury (Benares)	Chemistry	2 months.
4.	Mahendra Prakash (Agra)	Entomology	2 months.
5.	A. Veerayya (Madras)	Dairy	3 months.

(e) *Honorary Research Workers.*

1.	S. Govindaswamy (Coimbatore) ...	Cytogenetic and Morphological studies of interspecific and inter-generic hybrids of sugarcane.
2.	Rajendra Prasad (Delhi) ...	The Post Embryonic development of some of the parasitic hymenoptera.
3.	A. K. Das Gupta (Calcutta) ...	Soil Colloids.

APPENDIX III

Publications issued during 1945-46:—

Ahmad, T. and Mathur, I. D. (1945) .. Biology and ecology of *Melcha ornatipennis*. Indian J. Ent., 7: 21-36.

Bose, M. (1945) ... ... A new Coreid from Delhi. Indian J. Ent., 7: 75-78.

Bose, M. (1945) ... ... A new species of Curculionidae from Delhi. Indian J. Ent., 7: 85-88.

Das, S. (1945) ... ... Relative availability of different natural and artificial phosphates in calcareous soils. Indian J. Agric. Sci. Vol. XV, Pt. III, 130.

Das, S. (1945) ... ... Locust as food and manure. Ind. Farm. Vol. VI, No. 9, 412.

Das, S. (1946) ... ... Poisoning effect of feeding Barawadi grass to cattle. Ind. Farm., Vol. VII, No. 2, under 'What would you like to know'.

Desai, S. V. & Sen, A. (1945) ... Studies on the alkaline patches at Pusa, *Ibid.*

Desai, S. V. & Sen, A. (1945) ... A suggested simplification of the mechanical Analysis of soils. *Ibid.*

Dutt, N. L. (1945) ... ... A review of the Genus Saccharum Indian Farming 6,581.

Dutt, N. L. and K. V. Gopal Iyer, (1946) ... Nitrogen content and yield of sugarcane, Proc. 33rd Ind. Sci. Congr., Part III, p. 164.

Dutt, N. L. and Vijayasaradhy (1946) .. Storage and fertilising capacity of sugarcane pollen. Proc. Ind. Sci. Congs. Part. III, p. 165.

Dutt, N. L. Krishnaswami, M. K., and Hussainy S. A. (1946) ... Peth in cane and cane seedlings, Proc. 33rd Ind. Sci. Congress, Part III, p. 166.

Dutt, N. L. and Thuljaram Rao J. (1946) ... ... The present position regarding the taxonomy of *Saccharum* allied general, proc. 33rd. Sci. Congr. Part III, p. 107.

Haroon Khan, M. (1945) ... ... Driving hopper-bands of desert locust to the trenches. Indian Farming, 6: 296-299.

Haroon Khan, M. and Verma, P. M. (1945) ... ... Biology of the common parasites of Earias spp. Indian J. Ent., 7: 41-63.

Mundkur, B. B. (1946) ... ... Revisions of and Additions to Indian Fungi I. *Mycological paper Imperial Mycol. Inst. 16.*

Mundkur, B. B. and Pal, B. P. (1945) ... Studies in Indian Cereal Smuts VII. Further studies in varietal resistance of Indian and other wheats to loose smut. *Indian J. Agric. Sci. 15* 106-108.

Mundkur, B. B. and Mhatre, J. R. (1945) ... ... The *Synchytria* of India. *Lloydia*, 8: 131-138.

Mundkur, B. B. and Thirumalachar, M. J. (1945) ... ... Two new genera of rusts on Bignoniaceae. 37: 619-628.

Mundkur, B. B. (1946) ... ... Imported grain, a warning. Indian Farming VII. 4.

Mundkur, B. B. (1945) ... ... Controlling Plant Diseases. Indian Farming (in press),

Mundkur, B. B. (1945) ... ... Revisions of and Additions to Indian Fungi II *Mycological paper Imperial Mycological Inst.* (in press).

Muzaffar Ahmad (1945) ... ... Some new species of parasitic-Hymenoptera from India. Indian J. Ent. 7 : 5-11.

Nanda, K. K. and Chinoy, J. J. (1945) Effect of photoperiodic treatment on pollen fertility. Curr. Sci. 14 : 241.

Nasir, M. (1946) ... ... D. D. T. and 666 and insect pests of stored grains. Curr. Sci., 15 : 98-99.

Pal, B. P. (1946) ... ... Botany and Human Welfare. Proc. 33rd Indian Sci. Congs. Part II, 97-112.

Pal, B. P. and Mundkur, B. B. (1945) ... Studies in Indian Cereal Smuts. VII. Further studies in varietal resistance of Indian and other wheats to loose smut. Ind. J. Agri. Sci. 15 : 106-08.

Pal, B. P. and Ramanujam, S. (1944) ... Plant breeding and genetics at the Indian Agricultural Research Institute, New Delhi. Ind. J. Genet. Pl. Breed., 4 : 43-53.

Pal, B. P. and Ramanujam, S. (1945) ... Recent advances in the technique of plant breeding and seed multiplication for increasing the yield and production of crops under Indian conditions. Meeting of the Crops and Soils Wings of the Imperial Council of Agricultural Research, December, 1945, pp. 1-19.

Pradhan, S. and Iyer, K. P. V. (1945) .. Utility of statistical methods in Entomological Research. Indian J. Ent., 7 : 243-247.

Pruthi, H. S. and Nasir, M. (1945) ... Tests with D. D. T. and 666 as agricultural insecticides in India. Indian Farming 6 : 506-510.

Parthasarathy, N. and Subba Rao, K. S. (1946) ... ... Chromosome Survey of *Saccharum* spontaneum ; Proc. 33rd Ind. Sci. Congr., Part III, p. 110.

Rao, W. V. B., Desai, S. V. and Reddy, M. K. (1945) .. .. Studies on the methods of estimating total bacterial counts in the soil. Ind. J. Agri. Sci. 15, 111.

Rao, W. V. B. S. (1945) ... ... Some aspects of the effects of manuring on crop composition. Proc. Ind. Soc. Soil Sci.

Ramanujam, S. (1946) ... Recent advances in breeding for disease resistance in plants. Abst. Proc. 33rd Indian Sci. Congr., Bangalore, January, 1946.

Raychaudhuri, S. P. (1946) ... Soils of India and Soil Survey. Ind. Farming Vol. VII, No. 3, pp. 121-23.

Sen, A. (1945) ... ... A new method for the estimation of total solids of soil extracts and water. I. J. A. Sci. (in press).

Sen, A. (1945) ... ... Occurrence of summer dust over Delhi. Cur. Sci. October, 1945.

Sen, A. (1945) ... ... Raising crops without manure. Proceedings of the Ind. Sci. Cong. 33rd Session, Bangalore.

Sen, A. (1945) ... ... Recent Experiments on manuring. *Ibid.*

Sen, A. (1945) ... ... Calculation of starch from moisture in potato. *Ibid.*

Siddiqui, R. H. (1945) ... ... A note on rubber from Lobelia excelsa and Chonemorpha macrophylla. J. Ind. Chem. Soc. and News Ed. 8, 63,

Siddiqui, R. H., and Rao, W. B. V. S. (1945) ... ... Cryptostegia grandiflora. A war time source of vegetable rubber. Part II, Fermentation studies Ind. J. Chem. Soc. Ind. and News. Ed., 8, 18.

Siddiqui, R. H., Warsi, S. A. and Sastry, V. V. K. (1945) ... ... Cryptostegia grandiflora. A war time source of vegetable rubber. Part IV, Mechanical extraction J. Ind. Chem. Soc. Inds. News Ed. 8, 24.

Siddiqui, R. H. and Warsi, S. A. (1946) ... ... Cryptostegia grandiflora. A war time source of vegetable rubber, Part VII. Composition and properties of latex and rubber. J. Ind. Pharm. 7, 117.

Siddiqui, R. H. and Warsi, S. A. (1945) Cryptostegia grandiflora. A war time source of vegetable rubber. Part VIII. Examination of the seeds and the fatty oil. J. Ind. Pharm. 7, 75.

Siddiqui, R. H. (1945) ... ... Extraction of sulphur from its ores. J. Ind. Chem. Soc. Ind. and News Ed. 8, 104.

Ukil, A. C., Vyas, N. D., and Viswanath, B. (1944) ... ... Comparative studies on Indian soils I. The composition of clays from soil profiles. Ind. J. Agr. Sci. XIV, V, 345-363.

Vasudeva, R. S. and Pavgi, M. S. (1945) ... ... Seed transmission of Melon Mosaic Virus. Curr. Sci. October, 14.

Vasudeva, R. S. (1946) ... .. Virus diseases of Potatoes in India. Ind. Farming, VII, 4.

Viswanath, B. and Ukil, A. C. (1944) ... Comparative studies on Indian Soils. I Regional and Environmental factors associated with Indian soils. Ind. J. Agr. Sci. XIV, V 333-344.

Vyas, N. D. (1946) ... ... The use of ammonium nitrate, a surplus ammunition product. Proc. Ind. Sci. Congr.

Yusuf, N. D. (1946) ... ... Inducing flowering in non-flowering sugarcanes. Curr. Sci., 15, 164-166.

Yusuf, N. D. and Dutt, N. L. (1946) ... Photoperiod in relation to flowering in sugarcane. Current science, 14, 304-306.